Control ENGINEERING

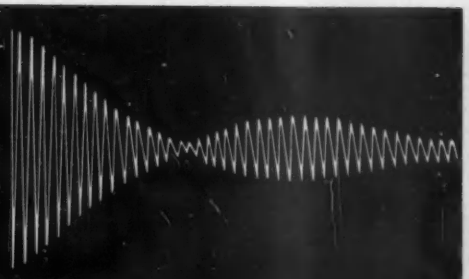
INSTRUMENTATION AND CONTROL SYSTEMS

A McGraw-Hill Publication

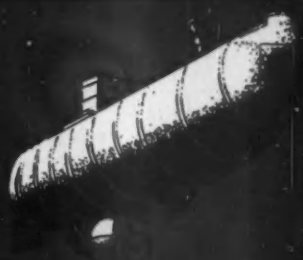
75 Cents

AUGUST 1961

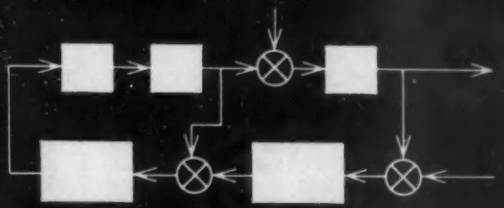
Step Inputs Test Rate Gyros Fast



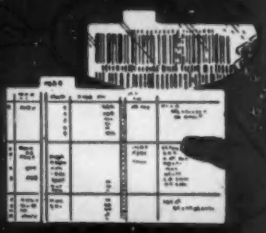
The Market for Underwater Instrumentation



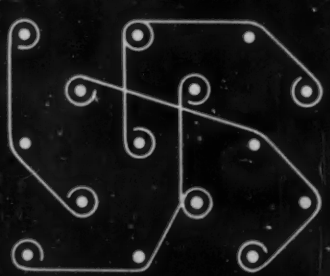
Cascade Control Reanalyzed

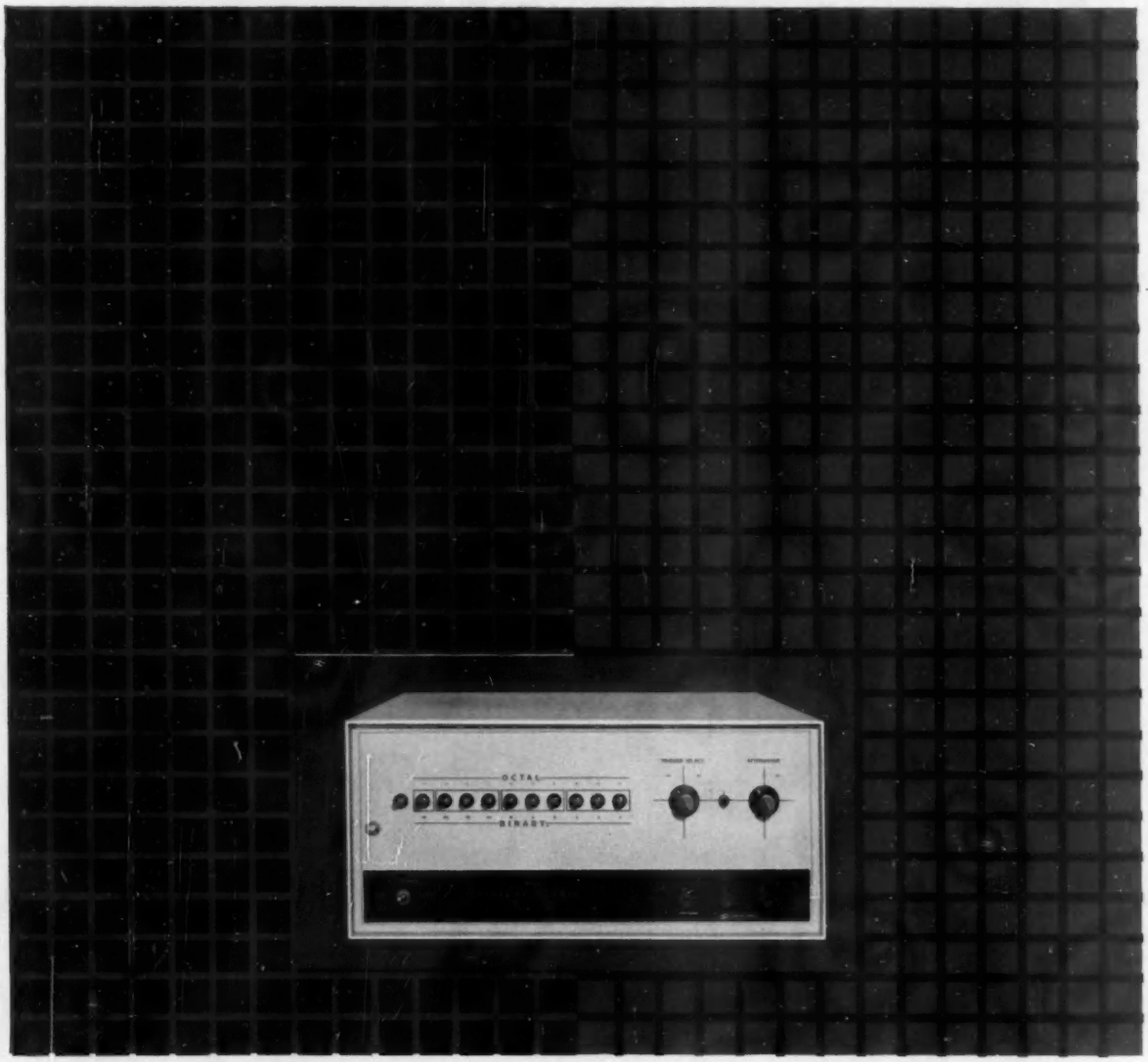


New Business-Order Data Entry System



Programmed Machine Wires Control Panels





INTRODUCING LIBRASCOPE'S ELECTRONIC DIGILOG*-1011 FOR VOLTAGE-TO-DIGITAL/DIGITAL-TO-VOLTAGE CONVERSIONS

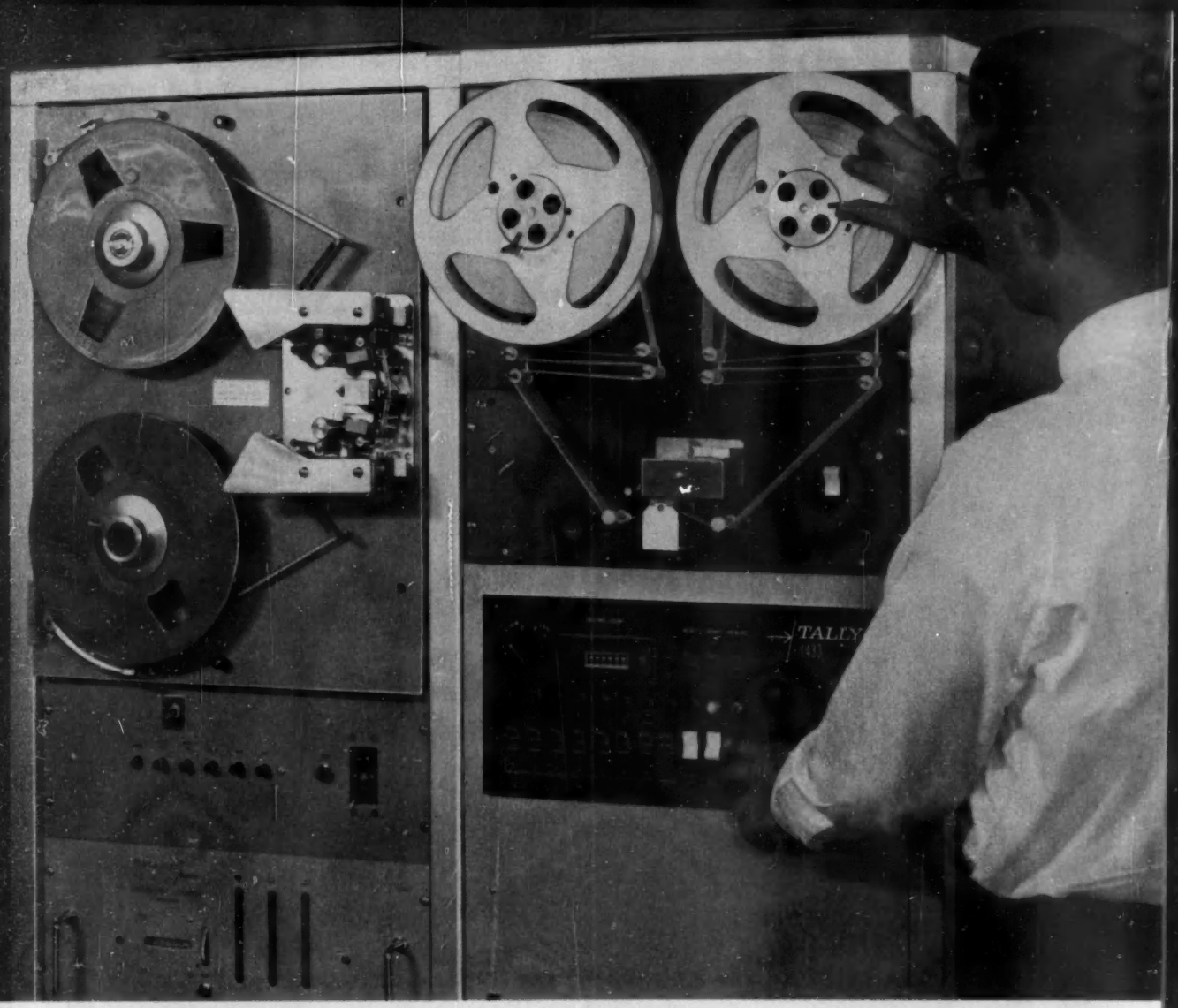
Use it as a precision input unit with computers, data loggers, storage units and other instrumentation. Use it wherever conversions must be fast and accurate. For the DIGILOG-1011 performs up to 5,000 voltage-to-digital conversions per second, 100,000 digital-to-voltage per second. Digital output is 10 bits plus sign in binary and octal code, and may be serial or parallel. DIGILOG-1011's low-density component packaging results in solid-state circuitry offering exceptional reliability and life expectancy, and low initial cost. DIGILOG-1011 accepts inputs in these full-scale ranges: ±1.023v, ±10.23v, ±102.3v. Accuracy is ±0.03% ±½ bit, and stability is ±0.03%. Input resolution: 1 mv minimum. *For technical details on the* DIGILOG-1011, *write or call Librascope today.*

*TRADEMARK, GENERAL PRECISION, INC.

GENERAL PRECISION

LIBRASCOPE DIVISION | GENERAL PRECISION INC., GLENDALE 1, CALIFORNIA

CIRCLE 179 ON READER SERVICE CARD



How to convert perforated to magnetic tape at a reasonable cost (NOW)

Tally's new solid state Model 1433 Paper-to-Magnetic Tape Converter is not 10 years ahead of its time. You can solve today's media conversion problems with both integrity and economy.

Normally, input and output data are completely identical in content. The output record is a bit for bit image of input data. A universal code conversion feature is, however, available.

Without changes or adjustments, the Tally converter will accept paper, foil, or plastic tapes in widths varying from 5 through 8 levels. It writes data on magnetic tape compatible with IBM 727, 729 Mod 1, and Remington Rand computer formats. Other formats are also available.

Complete in itself, the system includes a 120 cps paper tape reader, a Potter magnetic tape handler, and necessary electronics. Price of the Model 1433 begins at $26,500. Delivery is currently 120 days. More information can be obtained from your Tally engineering representative or by writing

SEE US AT WESCON—BOOTH 2516

CIRCLE 2 ON READER SERVICE CARD

TALLY
REGISTER CORPORATION
1310 Mercer Street • Seattle, Washington
MAin 4-0760
OFFICES IN ALL MAJOR CITIES

Control ENGINEERING

AUGUST 1961
VOL. 8 NO. 8

Published for engineers and technical management men who are responsible for the design, application, and test of instrumentation and automatic control systems

Continued on next page ➧

IDEAS AT WORK

WHAT'S NEW IN THE CONTROL FIELD

CONTROL ENGINEERING, August, 1961, Vol. 8, No. 8. Published monthly by McGraw-Hill Publishing Company, Inc. Executive, editorial, circulation and advertising offices: 330 West 42nd Street, New York 36, N. Y. Printed in Albany, N. Y.: second class postage paid at Albany, N. Y. and at additional mailing offices. U. S. subscription rate for individuals in the field of publication: $3 a year. Further details p. 6. POSTMASTER: Please send Form 3579 to Fulfillment Manager, Control Engineering, 330 West 42nd Street, New York 36, N. Y.

Another CMC First...

100 mc SOLID STATE Universal Counter-Timer

5¼"

WEIGHT 25 LBS.

KEY SPECIFICATIONS

FREQUENCY
0 cps to 100 mc

TIME INTERVAL
0.02 μsec to 10^9 sec

PERIOD
0 cps to 10 mc

INPUT SENSITIVITY
1.0v rms

GATE TIMES (FREQUENCY)
1 μsec to 10 sec in 8 decade steps or external. Reads in cps, kc, mc.

FREQUENCY OUTPUTS
0.1 cps to 1 mc output in decade steps

ACCURACY
±1 count ± stability
±10 nanosecond ± stability

STABILITY
Short term: ±1 part in 10^8
Long term: within 5 parts in 10^8

PRICE, F.O.B. FACTORY
$3,950; inline readout $200 extra

∗ SEVEN BASIC FUNCTIONS, including dc to 100 mc frequency measurements without heterodyning techniques ∗ Time interval measurements with 10 nanosecond resolution ∗ Straight or totalizing counting ∗ Frequency ratio measurement ∗ Period measurement ∗ Sensitivity better than 1.0v rms ∗ Power consumption 50 watts ∗ Decade countdown time base (no adjustments necessary) ∗ Two year free service warranty ∗ No vacuum tubes ∗ Connector on rear providing standard 1-2-4-8 BCD output for operating printer, punch, etc.

Model 728B is a production unit, not a showpiece prototype. Demonstrators are now in the hands of CMC engineering reps. Call, wire or write to arrange a demonstration. Complete technical data plus a copy of our new 20 page short form catalog is yours for the asking.

See Us at WESCON, Booth No. 1524-25.

CMC 9 8 7 6 5 4 3 2 1 0

Computer Measurements Company

12970 BRADLEY AVENUE • SAN FERNANDO, CALIFORNIA
EMPIRE 7-2161

43

CIRCLE 5 ON READER SERVICE CARD

Control ENGINEERING

AUGUST 1961 VOL. 8 NO. 8

Published for engineers and technical management men responsible for the design, application, and test of automatic control systems.

PRINT ORDER THIS ISSUE 34,808

Published monthly by McGraw-Hill Publishing Company, inc. Founder James H. McGraw (1860-1948). EXECUTIVE, EDITORIAL, CIRCULATION, and ADVERTISING OFFICES McGraw-Hill Building, 330 West 42nd Street, New York 36, N. Y. Telephone: LOngacre 4-3000. Teletype: TWX N. Y. 1-1636. Cable address McGRAW-HILL, N. Y.

OFFICERS OF THE PUBLICATIONS DIVISION: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator; Daniel F. Crowley, Vice President and Controller.

OFFICERS OF THE CORPORATION: Donald C. McGraw, President; Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Executive Vice President and Treasurer; John J. Cooke, Vice President and Secretary.

Printed in Albany, N. Y.; second-class mail postage paid at Albany, N. Y. and at additional mailing offices. Title ® reg. in U. S. Patent Office. © Copyright 1961 by McGraw-Hill Publishing Co., Inc. All rights reserved, including the right to reproduce the contents of this publication, either in whole or in part.

TITLE AND COMPANY CONNECTION MUST BE INDICATED ON SUBSCRIPTION ORDERS forwarded to address shown in box below. Publication is available only by paid subscription. Publisher reserves the right to refuse nonqualified subscriptions. Single copies, 75¢, except $2 for September issue. U.S. and Canada one year, $5. Foreign: one year, $15.

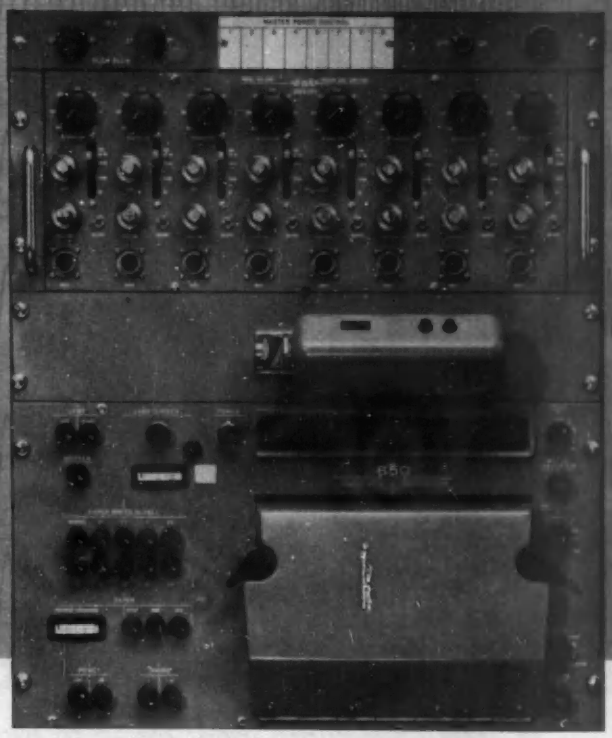
UNCONDITIONAL GUARANTEE: Our aim is to provide subscribers with a useful publication. Your comments and suggestions for improvement are encouraged and will be most welcome. The publisher, upon written request, agrees to refund the part of the subscription price applying to the remaining unfilled portion of the subscription.

SUBSCRIBERS: Please address all correspondence, change of address notices, subscription orders or complaints to Fulfillment Manager, CONTROL ENGINEERING, 330 West 42nd Street, New York 36, N. Y. Change of address notices should be sent promptly; provide old as well as new address; include postal zone number, if any. If possible, attach address label from recent issue. Copies of publications are addressed one to two issues in advance; therefore please allow one month for change of address to become effective.

POSTMASTER: Please send form 3579 to Fulfillment Manager CONTROL ENGINEERING 330 W. 42nd St., N. Y. 36, N. Y.

ABC ABP

DC to 5000 cycles over an amplitude of 4" peak to peak



NEW SANBORN "650" SYSTEM OFFERS DIRECT READOUT, 8 TO 24 CHANNELS, ALL SOLID STATE CIRCUITS, FOR RACK MOUNTING OR INDIVIDUAL CASES.

Here's the *one* system that lets you record inputs from DC to 5 KC within 3 db at 4" peak-to-peak amplitudes, without changing galvanometers. The "650" system consists of an 8-channel medium gain, general purpose amplifier unit driving a high speed, high resolution optical oscillographic recorder. It can be easily built into your system, packaged in a mobile cabinet or housed in individual cases. The single-chassis, 7" high amplifier module has 8 separate channels, *complete from floating and guarded inputs to galvanometer outputs;* each channel comprises a front end modulator and input transformer, carrier amplifier, demodulator, filter and driver amplifier. Power Supply and Master Oscillator Power Amplifier are built-in. All amplifier elements are plug-in transistorized units for easy servicing.

Immediately readable recordings are made on 8" wide daylight-loading ultra-violet-sensitive charts which require no chemical development. Features of the 12¼" high recorder unit include 9 electrically controlled chart speeds from ¼" to 100"/sec; calibrated monitoring screen; automatic trace identification and timing lines at 0.01 or 0.1 sec. intervals; amplitude lines spaced 0.1" apart which can be blanked from ¼, ½, ¾ or all of chart. Recorder is available with an 8-, 16- or 24-channel galvanometer block which is then equipped with the number of galvanometer elements desired by the customer. Either the Recorder or Amplifier are also available as individual units for use with other equipment.

SENSITIVITY 20 mv input gives 8" deflection; 12 attenuator steps to X5000, smooth gain control.

INPUT RESISTANCE 100,000 ohms all ranges, floating and guarded; DC source resistance must be kept below 1000 ohms on mv ranges only.

COMMON MODE PERFORMANCE Rejection at least 140 db at DC, tolerance to ±500 volts, max.

GAIN STABILITY Better than 1% to 50° C. and for line voltage variation from 103 to 127 volts.

LINEARITY 1½% of full scale (8 in.)

NOISE 0.02" peak-to-peak, max.

MONITOR OUTPUT On front panel; provides ±1v full scale across 100,000 ohm load

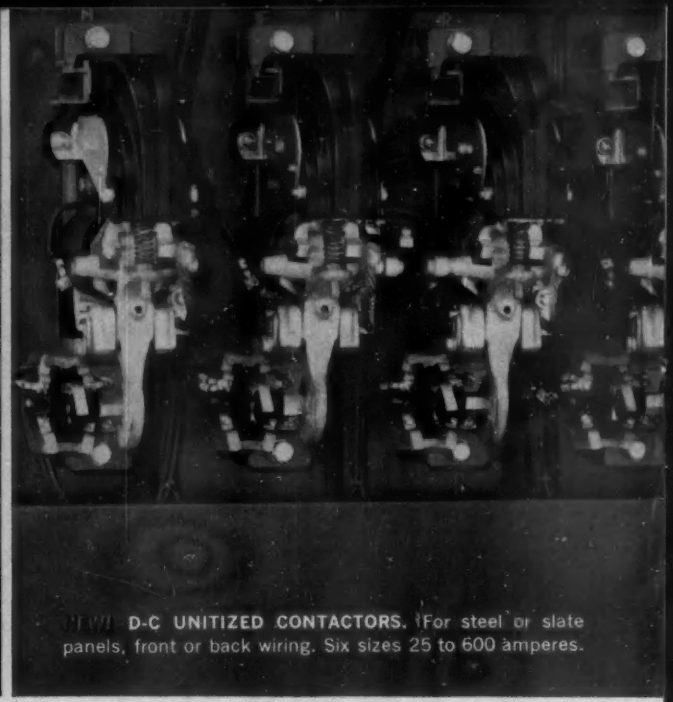
POWER REQUIREMENTS 103-127 volts, 60 cycle AC, 625 watts

Contact your Sanborn Sales-Engineering Representative for complete specifications and applications engineering assistance. Offices throughout the U. S., Canada and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman St., Waltham 54, Massachusetts

CIRCLE 7 ON READER SERVICE CARD

NEW! COMPACT 300 VOLT CONTROL RELAY Space-savingest relay ever! So reliable it is permanently enclosed.



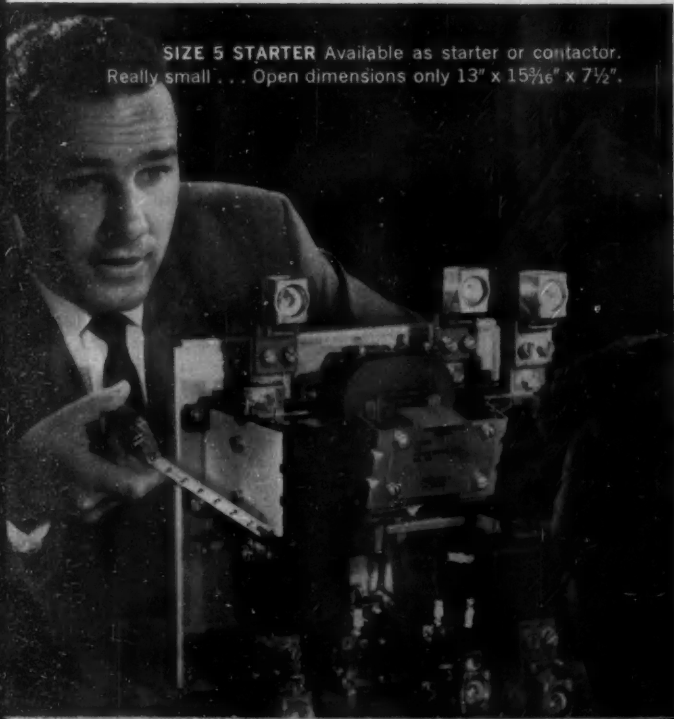
NEW! D-C UNITIZED CONTACTORS. For steel or slate panels, front or back wiring. Six sizes 25 to 600 amperes.

New from Cutler-Hammer

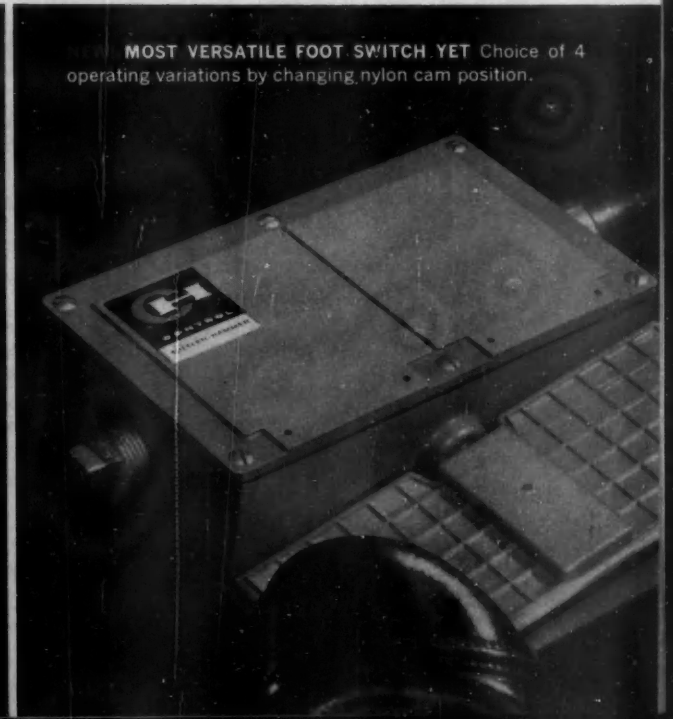
New products, new ideas to help your business now

The air is charged with new ideas at Cutler-Hammer . . . ideas and products resulting from our new production facilities, new engineering talent, new research programs, and most important of all—*a new desire to serve you better in the sixties.* Evidence of this vitality and what it can mean to you are these eight typical new products.

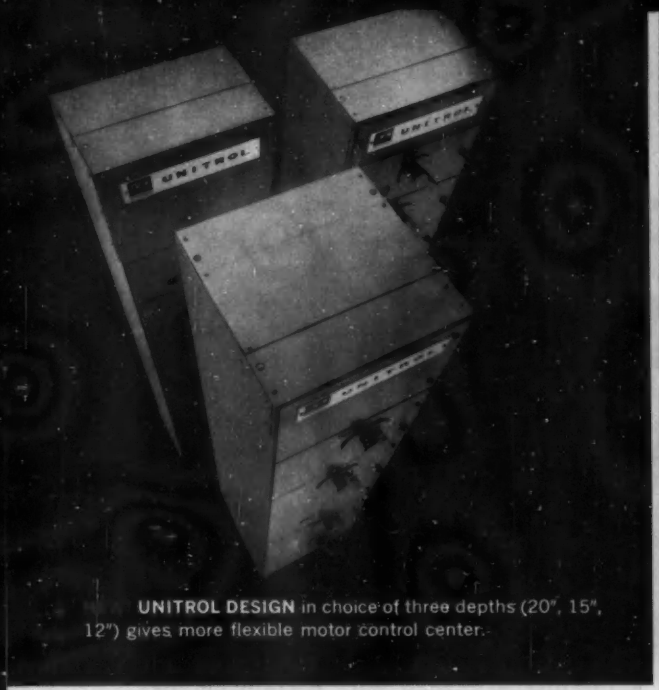
You can expect more news from Cutler-Hammer around the calendar. Give your Cutler-Hammer sales office or distributor a call. They're all charged up too—anxious to tell you more about *what's new at Cutler-Hammer.* For descriptive literature on any of these products, write Cutler-Hammer or call your nearest Cutler-Hammer distributor.



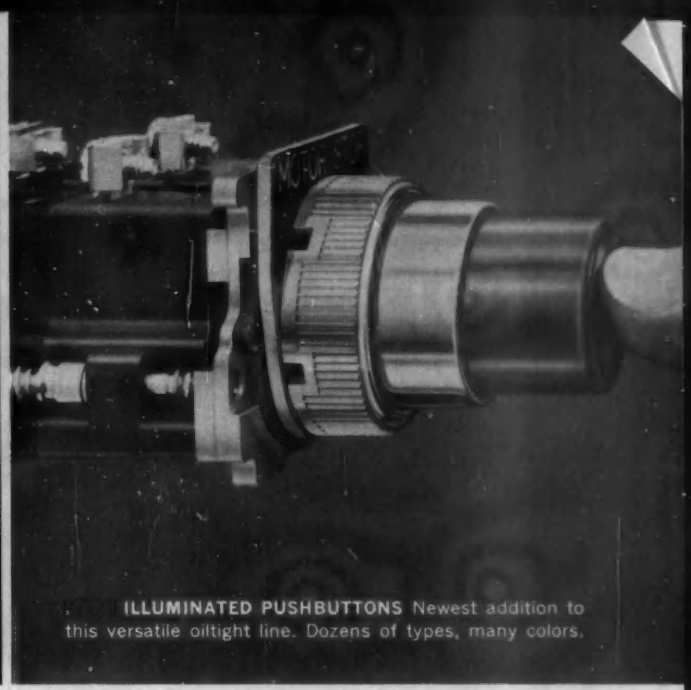
SIZE 5 STARTER Available as starter or contactor. Really small . . . Open dimensions only 13" x 15 5/16" x 7½".



MOST VERSATILE FOOT SWITCH YET Choice of 4 operating variations by changing nylon cam position.



UNITROL DESIGN in choice of three depths (20", 15", 12") gives more flexible motor control center.



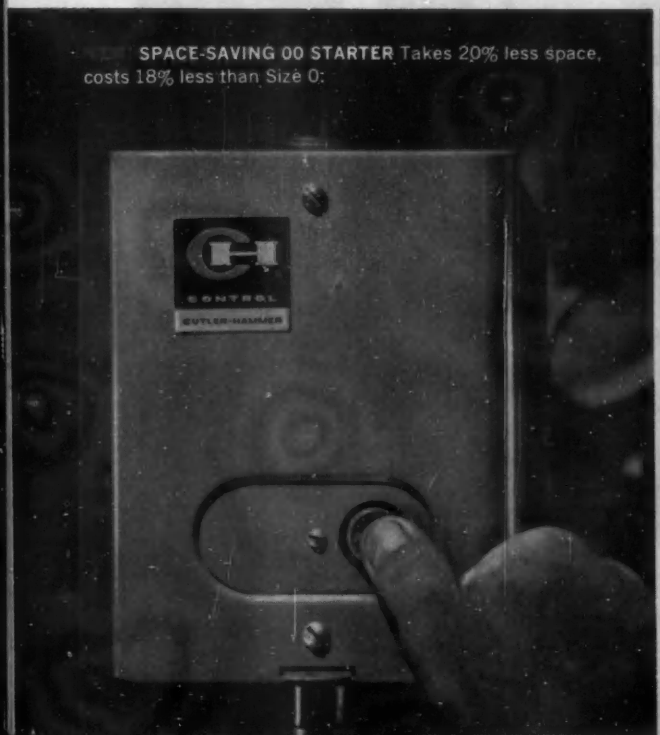
ILLUMINATED PUSHBUTTONS Newest addition to this versatile oiltight line. Dozens of types, many colors.

WHAT'S NEW? ASK...

CUTLER-HAMMER

CONTROL

SPACE-SAVING 00 STARTER Takes 20% less space, costs 18% less than Size 0:



MOST RELIABLE LIMIT SWITCH EVER This oiltight switch outlasts others by far. Many operator options.

SHOPTALK

Solid state in control: September issue

A solid state inertial guidance system with atomic phenomena replacing the gyros and ferroelectric materials instead of accelerometers. A truly digital pressure measuring device in which the output results from the absorption of nuclear radiation. A data transmission technique with a theoretical capacity approaching 80 million television channels. These three dramatic examples are not simply Jules Verne creations. CONTROL ENGINEERING editors, below, uncovered intensive work under way on these and hundreds of other startling projects in the course of preparing next month's special issue on SOLID STATE IN CONTROL.

But the impact of solid state is not for tomorrow alone. Hardware and techniques are commercially available today with a flexibility and reliability undreamed of 20 years ago. The big September issue will put the solid state revolution in perspective. It is the first time solid state phenomena and applications have been tailored for the control engineer's interest and background. Sixty feature-article pages will report how solid state equipment increases the capability of every part of the control loop.

You won't want to miss this special report.

Editorial head count

Recently expanded, here's the staff that keeps you the world's best-informed readers on all developments in control.

B. K. Ledgerwood

L. H. Young

E. J. Kompass

M. P. Southworth

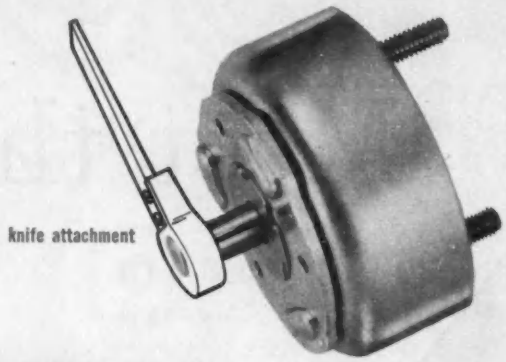
J. Gordon

H. R. Karp

D. Barlow

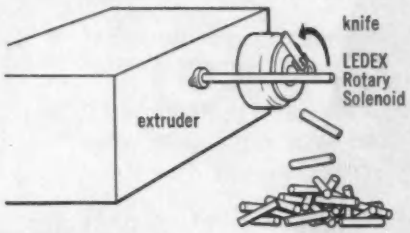
S. S. Livers

R. F. Heslen



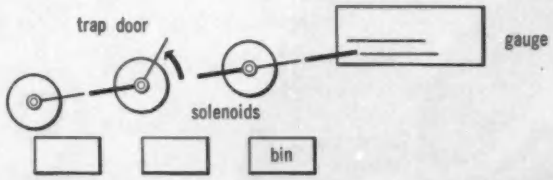
Compact Solutions with Ledex Rotary Solenoids

CUTTING



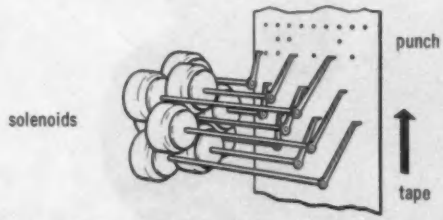
In this example a Rotary Solenoid has a knife attachment for cutting a plastic material that is extruded continuously. The speed of the solenoid is so fast that the material needs no additional support.

SORTING



Here parts to be sorted first pass through a gauge. The gauge measures each part and activates a Rotary Solenoid to open a trap. Sorting could be by size, weight, electrical capacity, or any type of quality control.

PUNCHING



The quick snap action of a Ledex Rotary Solenoid (about 1/20 second) meets requirements for high-speed tape punching. In this example, solenoids have arms attached to shaft extensions of varying lengths, providing a compact unit of solenoids that requires small space.

The examples shown above have one thing in common. They fit into compact space. Design engineers, for example, often find that a Ledex Rotary Solenoid will fit into one-quarter to one-half the space of a straight pull solenoid.

This compactness results from the unique Ledex design which converts an efficient short axial stroke into a high torque to size rotary motion. A more uniform force is produced throughout the stroke, making use of otherwise wasted energy at the end of the stroke. This rotary motion can be used directly as in the cutting and sorting examples above, or can be converted into linear motion, as in the punching example.

Ledex Rotary Solenoids come in 8 compact sizes, with operating voltages from 3 to 350 VDC. Choice of over 250 stock models ready for immediate shipment.

Other Ledex products are ready to go to work as compact solutions to your actuating, stepping or circuit switching applications. Write for literature mentioning application to Ledex Inc., Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.; AEMGP, 115 Ave. Clement, Boulogne, France.

LEDEX®

High-torque-to-size rotary motion
High-thrust-to-size piston motion

Meet the

New DAYSTROM Man

Who Brings You Coordinated Procurement of Gyros . . . Servos . . . Synchros . . . Transducers

- He represents, as a sales engineer, not one, but *several* coordinated Divisions of Daystrom.
- He's trained and equipped to discuss product capabilities and application in *many* component areas.
- This flexibility enables him to serve you in many more ways—far more often—far more effectively—far more deeply, especially where work with engineering departments is required.
- He's backed up by the specialized field engineering forces of each of the divisions he represents.
- He brings you *unified responsibility*—in delivery, product quality and compatibility all of which equates with considerable economy for you.
- You'll find your Daystrom Sales Engineer helpful in more efficient component procurement. Make full use of his services. Call:

Atlanta, Ga.	CE 7-8278	Redwood City, Calif.	EM 9-4871
Bedford, Mass.	CR 4-6640	Seattle 4, Wash.	MU 2-3355
Chicago, Ill.	FL 4-7200	Washington, D. C.	RE 7-1366
Dayton, Ohio	AX 9-5241	West Caldwell, N. J.	CA 8-0240
Denver, Colo.	AC 2-4497		
Green Lawn, L. I., N. Y.	FI 7-6087	Gloucester, England	GL 20217
Los Angeles, Calif.	OR 0-7260	Cooksville, Ontario, Can.	AT 93191
Norristown, Pa.	BR 9-9800		
Pasadena, Calif.	SY 3-9164	Cable	DAYIN NEWARK

Or write Coordinated Procurement Services, DAYSTROM INCORPORATED, West Caldwell, N. J.

DAYSTROM, INCORPORATED

DAYSTROM - PACIFIC: vertical, free, and rate gyros • programmers • data recorders
DAYSTROM - TRANSICOIL: servo and synchro components • electromechanical assemblies • airborne instrumentation
DAYSTROM - WIANCKO: transducers for sensing pressure, force, acceleration • analog and digital dynamic measuring systems
OTHER PARTICIPATING DIVISIONS: ELECTRIC DIVISION • MILITARY ELECTRONICS DIVISION • WESTON DIVISION

FEEDBACK

Exponent jumped parenthesis

To the Editor—

In reference to Entry 4 of Table I of my article on saturation functions, published in the February 1961 issue of Control Engineering, the definition should be

$$\frac{6t}{T}\left[1-\frac{1}{3}\left(\frac{4t}{T}\right)^2\right]$$

instead of

$$\frac{6t}{T}\left[1-\frac{1}{3}\left(\frac{4t^2}{T}\right)\right].$$

S. Manabe
Mitsubishi Electric Manufacturing Co.
Amagasaki, Hyogo Prefecture, Japan

How did that sneak in?

To the Editor—

It has come to our attention that in the article "How Industry Sees Microminiaturization", in the April 1961 issue of Control Engineering, the term "Semi-Nets" is attributed to the integrated circuit device offered by Fairchild Semiconductor Corp.

"Semi-Nets" (for semiconductor integrated networks) is a trademark of the Sperry Rand Corp. and designates a line of integrated components currently being developed and manufactured by the Sperry Semiconductor Division.

Sperry Semiconductor presently manufactures this series of integrated components for computer and missile applications in pilot line quantities.

G. W. DeSousa
Marketing Manager
Sperry Semiconductor Div.
of Sperry Rand Corp.

A possible misunderstanding

To the Editor—

We are deeply concerned with the recent publication of the results of the P. R. Mallory survey, "How Industry Sees Microminiaturization", CtE, April 1961, page 115. We, of course, are not challenging the answers or opinions of the approximately 550 individuals contacted by Mallory. But we are hopeful that the recipient of the Mallory survey had a clear understanding of the MECA system before receiving the survey, for if he had not, he certainly would be misled by the description. Actually, we were quite surprised to see our MECA system listed as a microminiaturization technique.

In reality, MECA is a system for interconnecting microminiaturized circuits. Each of the techniques mentioned in the survey described a specific technique or process used to develop a functional circuit block or wafer. None of the techniques mentioned how these functions shall be interconnected together or maintained within a system. The many variations of the MECA packaging philosophy are intended to supply the interconnection and maintainability features required for use with each of the systems mentioned in the survey, as well as others.

To cite the complete misconception of MECA by the survey recipient, let us examine just one question: "How do you rank these techniques on overall usefulness to your company during the four time periods indicated?"

The cordwood technique was rated to be useful through 1965 and MECA only until 1961. To verify the enthusiasm the industry has begun to show for the association of MECA and cordwood, let us cite Bendix as an example. Bendix Radio Corp., Towson, Maryland, has established a separate section to market cordwood-type circuits for use in the MECA system. We have also been approached by several other manufacturers who wish to establish the same marketing capabilities. Certainly, these companies are not interested in a technique duration of only six months.

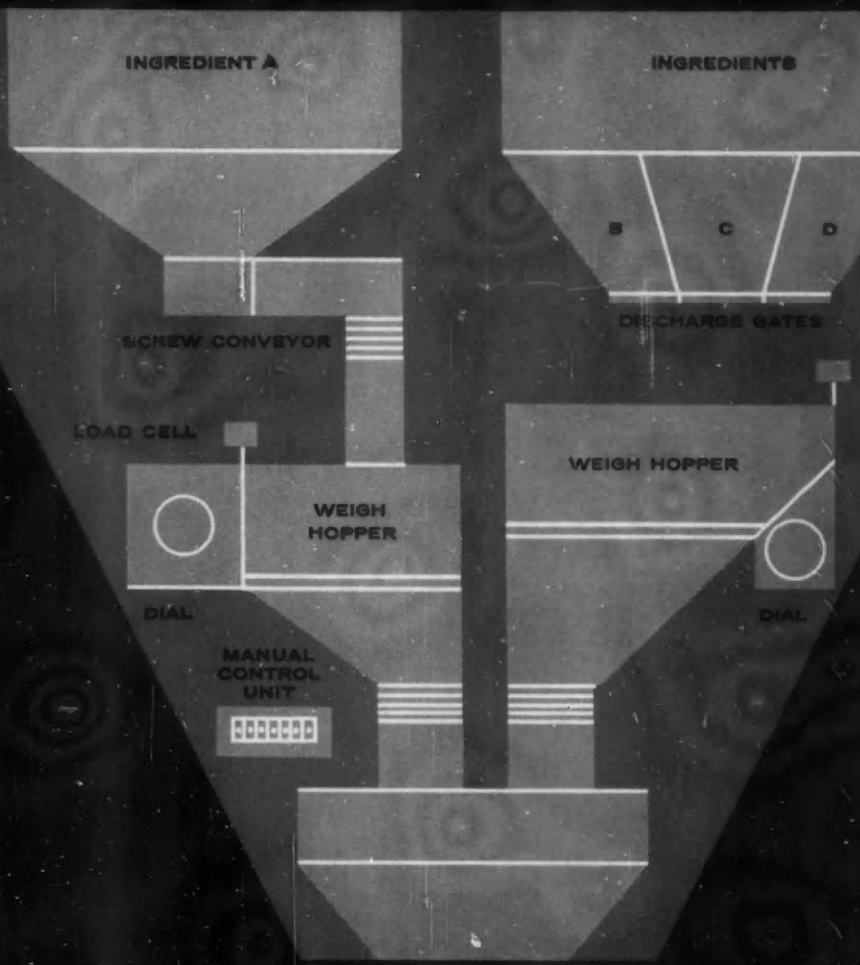
Harry Wasiele, Jr.
Product Sales Manager
AMP-MECA Section
AMP, Inc.

We too hope that there was no misunderstanding of the survey information. A convenient way of interconnecting and servicing microminiaturized devices is a must. Ed.

Another added entry

To the Editor—

With reference to Mr. Shaw's article on page 127 of February 1961 issue ("What's Available for Data Transmission"), Epsco, Inc. announced the availability of the Model DL-100 Digital Data Link, specifically designed



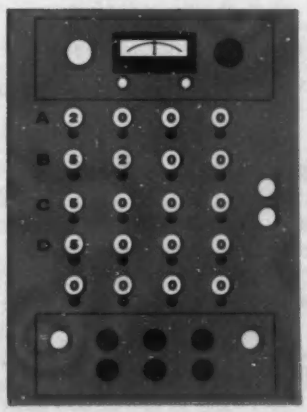
TIME SAVER... MONEY SAVER...

THE NEW FAIRBANKS-MORSE BATCHETRON

One of the latest developments in Fairbanks, Morse's 131 year experience in the weighing business is the *new* Batchetron. It is specifically designed for fast, accurate proportioning of any material that can be pushed, poured or dropped into weigh hoppers. It uses high-speed electronic methods to weigh and batch a number of liquids or solids—in sequence or simultaneously—by means of manual or punched card control.

The Batchetron is easy to set. Its high-speed action assures positive cutoff of ingredient flow. Interlocks prevent incorrect operation . . . halt operation if anything goes wrong. An improved, electronic weight-sensing system provides long, accurate, trouble-free service with exact batch repeatability every time. At all times control of operations is lightning fast.

The control panel of the Batchetron allows the operator to adjust for hopper tare weights, while pilot lights indicate batching startup, sequence and finish.



Use of the F-M Batchetron results in substantial time and money savings for the chemical and food industries . . . for concrete and asphalt batching plants . . . for the many applications where high-speed weighing and proportioning are important. And, of course, the many years of Fairbanks-Morse precision craftsmanship stand behind every Batchetron.

Learn what the Batchetron can do to make *your* operations more profitable.

Write: Fairbanks, Morse & Co.; Electronics Division; 100 Electra Lane, East Station; Yonkers, New York

ELECTRONICS DIVISION
FAIRBANKS MORSE
A MAJOR INDUSTRIAL COMPONENT OF
FAIRBANKS WHITNEY

CIRCLE 15 ON READER SERVICE CARD

FEEDBACK

for transceiver operation over communication circuits, over a year ago. The DL-100, with selfcontained magnetic tape recorder/reproducer, is capable of transmitting and receiving over telephone or teletype lines or microwave link at rates far in excess of those quoted. At the same time it will operate without modification within rates presently set by tariff and directly with the Bell Model 200 Data-phone subset. We trust you will note this oversight in an otherwise well documented review.

Robert E. Wright
Product Manager
Epsco, Inc.

In a forthcoming article covering error-correcting techniques in digital data links, Control Engineering hopes to include all equipments not discussed in Mr. Shaw's first article. Ed.

The curtain parts . . .

TO THE EDITOR—

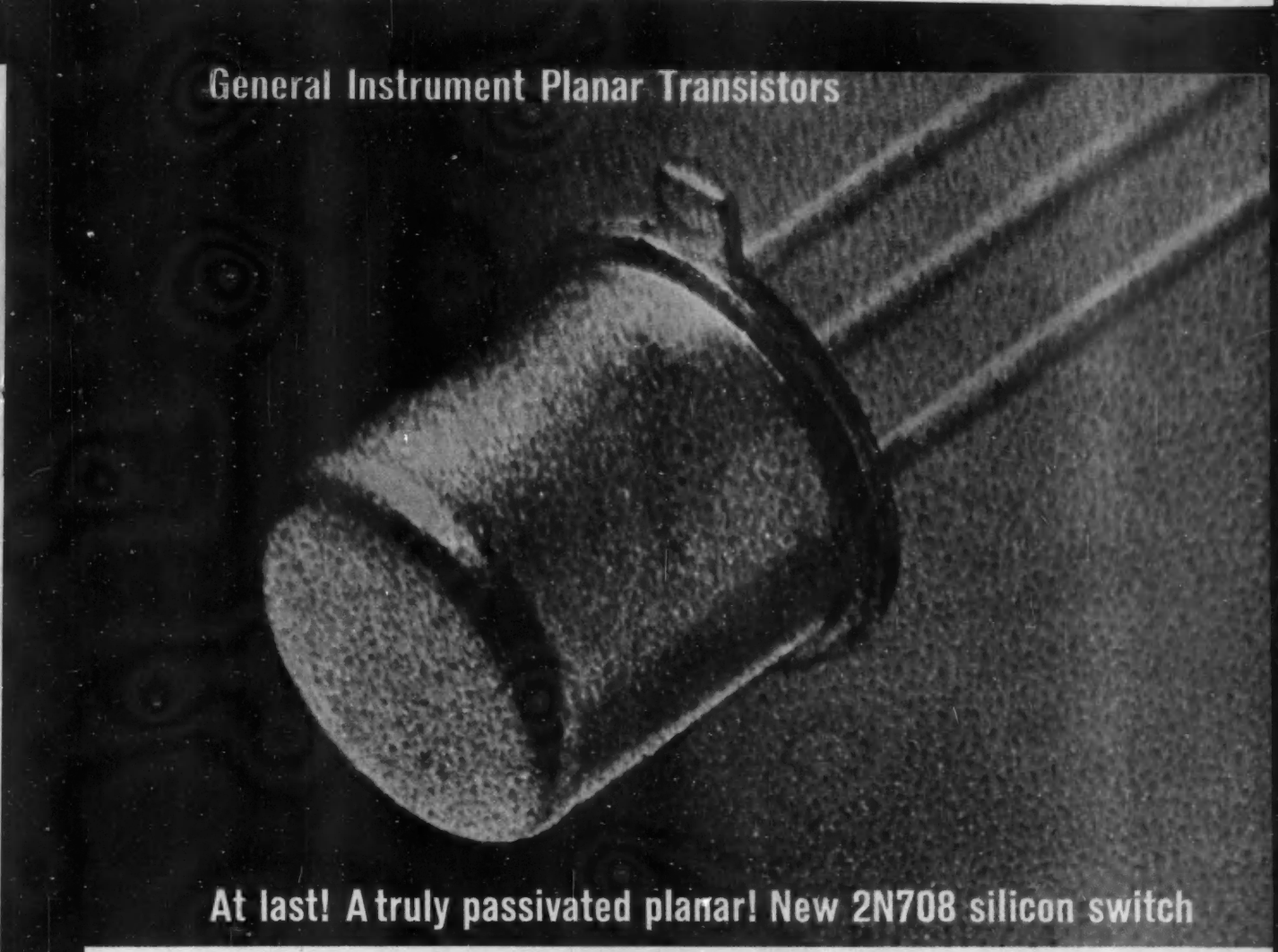
In the June 1960 issue of CONTROL ENGINEERING, page 27, a European Report on automation in Hungary quoted me five times in connection with statements on the "sad state" of Hungary's instrument industry. I immediately protested to you in detail on this distortion, which was followed by a long silence. Since you now finally agree to publish "10 cm in Feedback Column", please inform CtE readers as follows:

1) The "original report" was in fact a one-sided excerpt of a critical appraisal on Hungary's present five-year plan for the instrument industry, published over my signature by the Governing Board of our Society in the February 1960 issue of our journal "Mérés és Automatika", which is sent as a complimentary exchange copy for CtE. These facts were withheld from your readers.

2) Our Society and the Editorial Board of "Mérés és Automatika" disapprove of one-sided abstracting of this kind and offered that CtE publish a review of other articles from the same journal, reflecting the very significant advance of our instrument industry during the past 10 years despite growing pains. To date, CONTROL ENGINEERING has not used this material to correct the false picture previously presented to its readers.

Asst. Prof. Gy. Striker
Vice President, Hungarian Society for Measurement and Automation
(. . . and closes again. Ed.)

General Instrument Planar Transistors



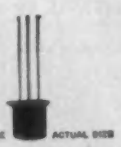
At last! A truly passivated planar! New 2N708 silicon switch

For high speed logic switching with assured reliability, the General Instrument 2N708 npn silicon planar switch features the unique Molecular Shield™ surface-passivation process. ■ Here's a planar that is stable, reliable and uniform...lot by lot...with excellent gain characteristics as well as extremely low leakage current. Designed for switching applications, this type, as well as others in the popular 2N706 class, utilizes the latest planar techniques. ■ Extensive tests have proved that this type of transistor construction offers definite circuit advantages. Life tests, for example, indicate little degradation as a result of operation and storage at high temperatures. ■ The immediate availability of the 2N706 series in production quantities should be of interest to designers now using our silicon mesa transistors. The 2N708 is also available in limited quantities. For microtransistors, pancake-package transistors...for all your silicon planar and mesa transistors, call the sales office or franchised distributor nearest you. Or write for complete details to General Instrument Semiconductor Division, 65 Gouverneur St., Newark 4, N.J.

Abbreviated Specifications—General Instrument NPN Silicon Planar Transistors

Type	V_{CBO}	V_{CER}	h_{FE}	T_S
2N706	25v	20v	20	60 nsec
2N706A	25v	20v	20	25 nsec
2N706B	25v	20v	20	25 nsec
2N708	40v	20v	30	25 nsec

GENERAL INSTRUMENT SEMICONDUCTOR DIVISION
GENERAL INSTRUMENT CORPORATION



CIRCLE 17 ON READER SERVICE CARD

PRESENTING M LINE

***M-LINE CONTROLLER** . . . heart of the M-Line Control system*

Not "just another" electronic miniature line . . . but the most advanced design for process control

Evaluate it yourself, against *your* control requirements. You'll quickly find that M-Line is the one miniature electronic control that's significantly different.

Based not only on L&N's direct experience in designing and building more than 70,000 electronic controllers, but incorporating as well many of the ideas suggested by instrument specialists in the process industries, this advanced instrumentation offers you a unique combination of advantages:

WIDEST SCOPE OF COMPATIBILITY IN OPERATION Can be used with virtually any commercially available primary element transmitter which produces a d-c current or voltage signal; can be integrated with data-handling or computing equipment;

SIMPLEST FUNCTIONAL DESIGN . . . Operation is uncomplicated, quickly understood by operators;

UNMATCHED INTERCHANGEABILITY OF COMPONENTS M-Line display and/or control units of varying sophistication can be readily substituted (simply plugged into the basic stations) even after installation and start-up;

OUTSTANDING FLEXIBILITY IN OPERATION AND IN APPLICATION . . . By-pass of signal to "end-operator" permits process operation even when various control system components are removed. Additionally, standard M-Line components form building-blocks for control systems of varying complexity.

Check the features listed . . . just a few of the engineering details that make M-Line an exceptionally sound and economical investment. Your local L&N representative has the full story . . . or for more detailed information write to Leeds & Northrup Co., 4918 Stenton Ave., Philadelphia 44.

LEEDS & NORTHRUP CO

M-LINE CONTROL STATION

Unitized construction—only 6″ x 6″ front-of-panel space required for complete one- or two-pen recorder and controller, including set-point unit, auto-manual unit, and control unit.

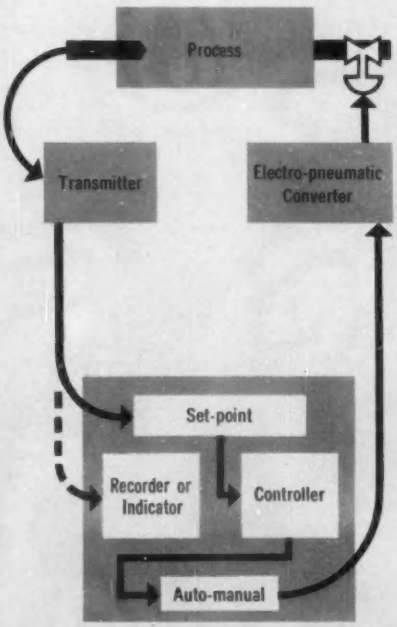
Simple auto-manual circuit design guarantees "bumpless" transfer from manual to auto, whether "on" or "off" control point—no balancing required. Easy to read—set-point index and measuring index use same calibrated scale.

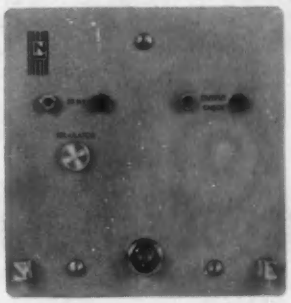
Controller transistorized, with high-impedance Nuvistor input stage—circuitry proved by years of industrial experience. Deviation from set-point will produce rate action, but due to circuit design, no rate upset is introduced when changing the set-point itself.

Control function adjustments in rear, to prevent tampering by unauthorized personnel.

Forward- or reverse-acting control achieved by switches, protected by foolproof locking plates; auto-manual station operation always the same, regardless of direction of control.

Available with 2- or 3-mode controllers. Proportional Band: 0–300%, continuous. Reset: Adjustable from 0.2 to 1000 repeats per minute for 2-mode controllers, 18 well-spaced steps; 0–100 repeats per minute for 3-mode controllers, 18 well-spaced steps. Rate: 0–8 minutes, continuous.





M-LINE TC/EMF TRANSMITTER

Measures any 0–5 to 0–60 mv d-c signal span from −60 to +60 mv.

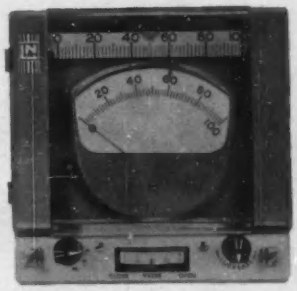
Transistorized circuits; Zener-diode reference.

All TC/EMF amplifiers interchangeable, regardless of application.

Range, reference junction compensation, and zero suppression resistors mounted on easily-changed card on terminal board.

Noise-free output signal with standard ranges of 1–5 ma or 0–4 ma into 500 to 2500-ohm load.

Input and output completely isolated—avoids grounding problems.



M-LINE INDICATORS

Available as one- or two-point indicators.

Clear, 3″ scale-length with continuous indication.

Easy to install and service; completely interchangeable with recorder—same case, same plug-in attachments.

LEEDS & NORTHRUP
Pioneers in Precision

SPEEDOMAX M RECORDERS

Available as one- or two-pen recorder with amplifiers completely encased.

4″ vertically-driven chart with continuous line record.

Potentiometric measurements of 4 v d-c (0–4 ma or 1–5 ma) using high-torque servo mechanism with optional retransmitting slidewires and high and low alarm contacts.

Recorder completely independent of the control circuit.

Recorder amplifier circuitry on printed cards for simplicity.

Sturdy 6″ x 6″ x 23″ case and rugged mounting —withstands rough handling and supports unusual loads.

Available with mercury-bottle disconnects for use in Class 1, Group D, Division 2, and many other safety features.

M-LINE ELECTRO-PNEUMATIC CONVERTER

Mounts in any position, in any location.

Resistant to vibration.

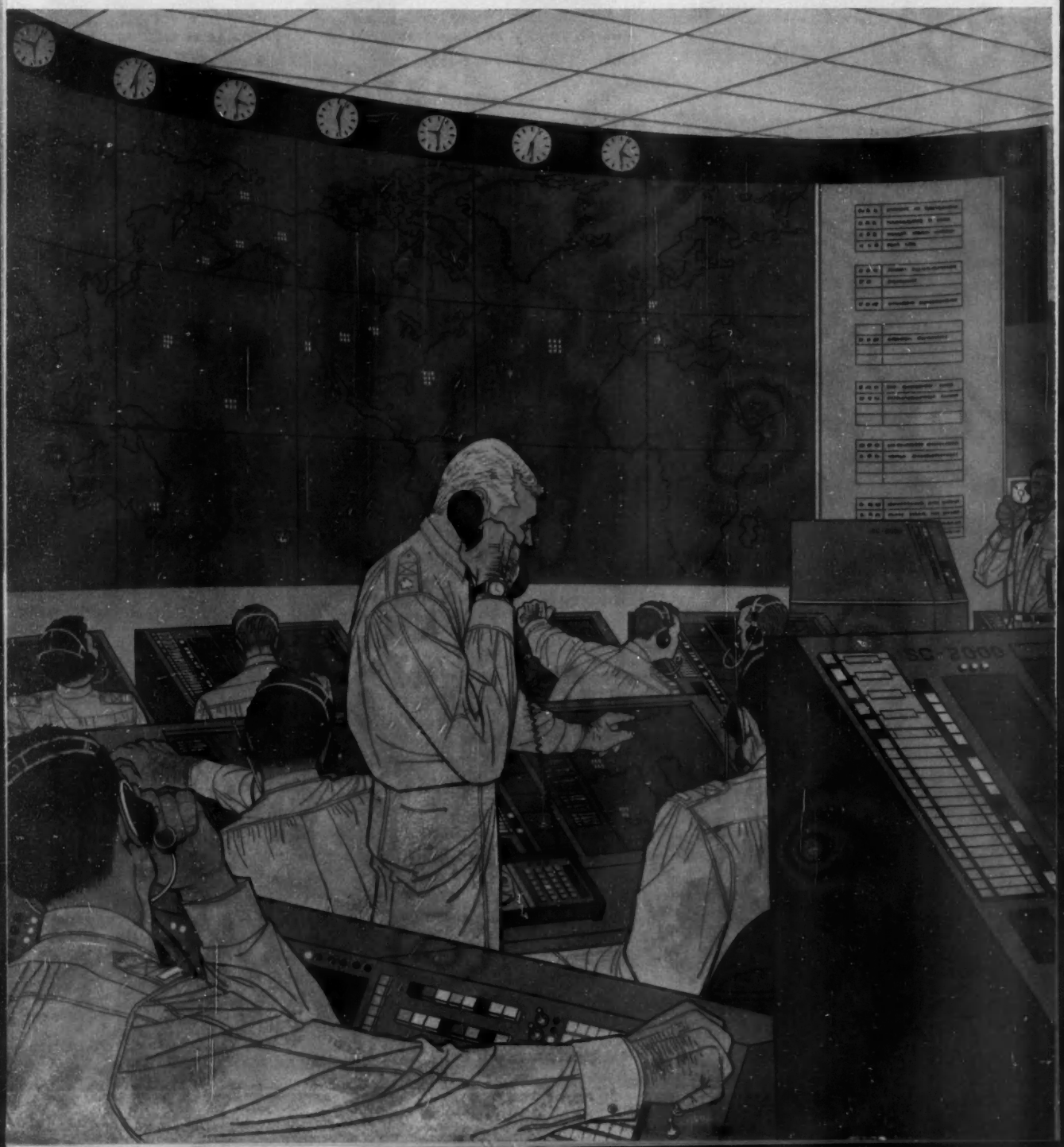
Weather-proof.

Maximum safety: uses minute energizing current, provides continuous air-purge of fumes.

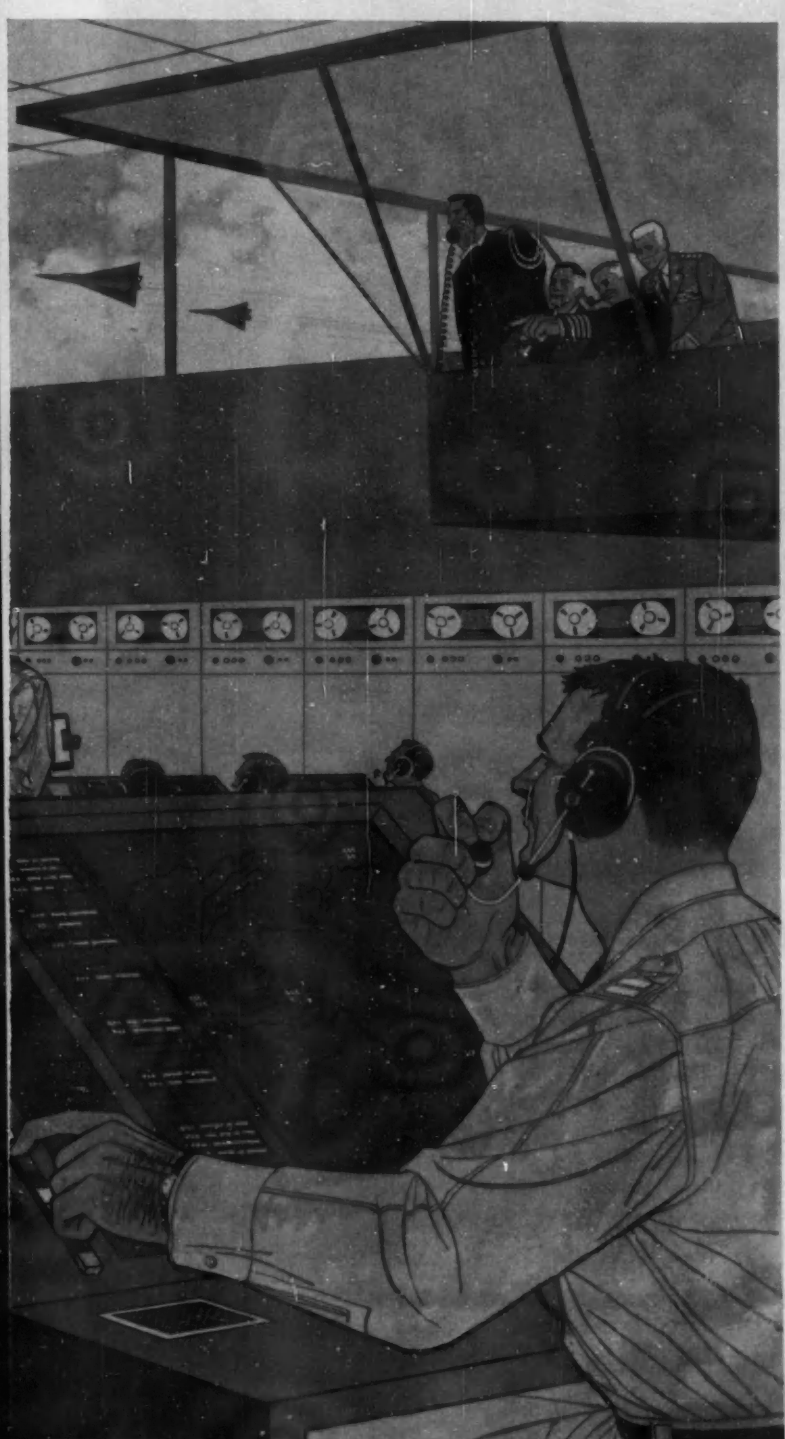
Pressure output can be locked-up, in event of power failure.

Can be used with any controller having a 1 to 5 ma d-c current output.

Less than 2 seconds from computer to large



screen display WITHOUT DARKENING THE ROOM!



The new, advanced S-C 2000 bright display system developed by General Dynamics/ Electronics produces an entire large screen display less than two seconds after data are transmitted from the computer. The unique yet simple principle of the S-C 2000 results in high-contrast storage displays with unsurpassed brightness and resolution for information presentation on both console and large screens.

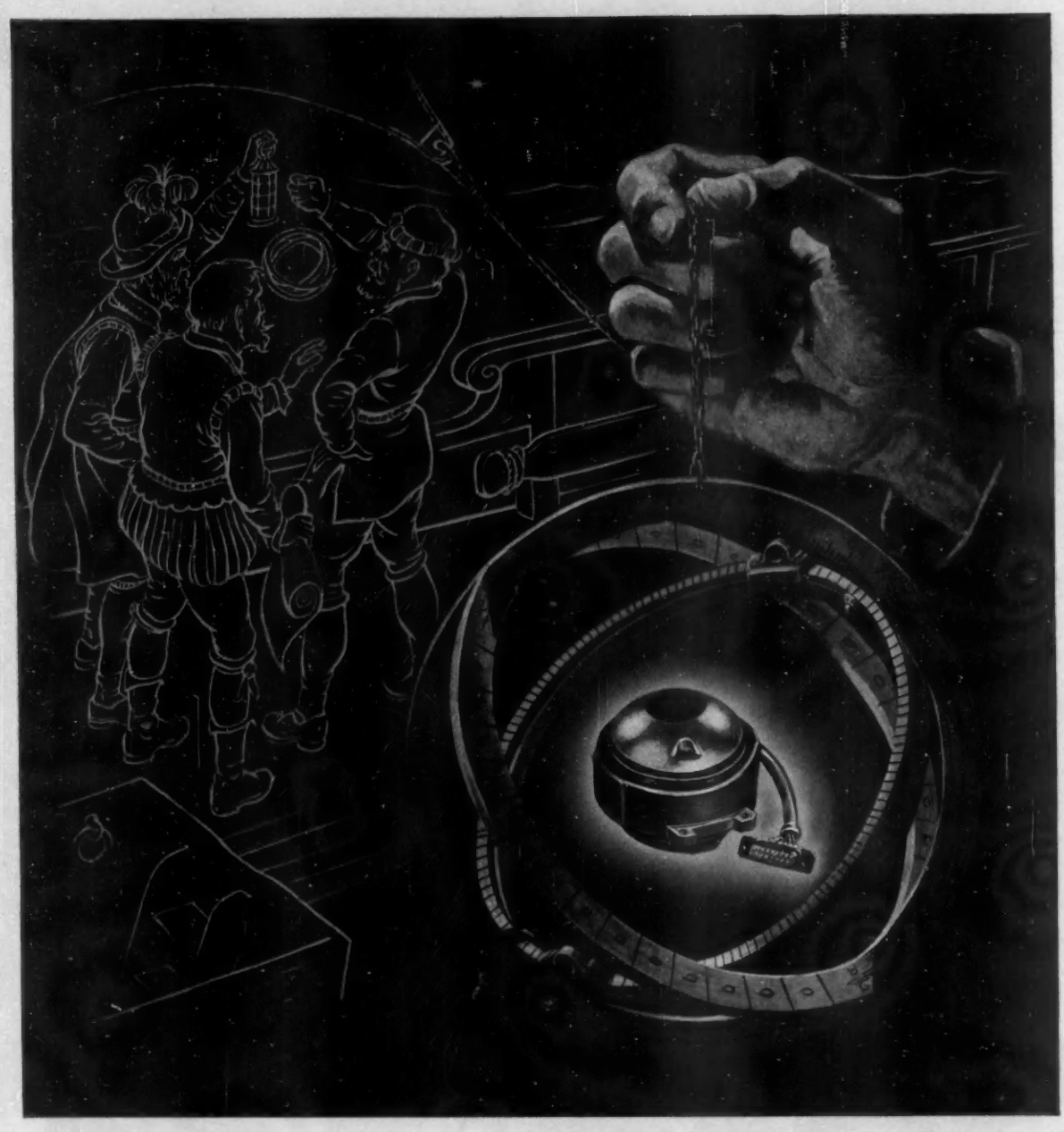
The S-C 2000 will display both video and alphanumeric data of all kinds simultaneously with any type of overlay. Display information need be transmitted only once from the data source owing to the inherent storage capability of the S-C 2000. The unit also provides both fail-safe retention of data and various types of permanent hard copy. Completely dry processing is incorporated with data rates of 40,000 separate characters per second. Scale changing, category commands and display selection are accomplished at the control console, without interrupting the computer.

A capability exists for seven color displays or data may be viewed as white against black or black against white. Resolution is 2000 lines on each axis. The S-C 2000 was developed under the auspices of the U. S. Air Force and Mitre Corp. If your requirements include computer display systems, we invite you to write for more information on the S-C 2000, a product of the company that produced the display control center for Project Mercury, General Dynamics/ Electronics, Information Technology Division, Dept. B-41, Box 2449, San Diego 12, California, or contact the representative in your area.

The first developmental S-C 2000 console delivered to Mitre Corp.

GENERAL DYNAMICS | ELECTRONICS

CIRCLE 21 ON READER SERVICE CARD



Navigation by sure eye and steady hand

Ferdinand Magellan successfully steered his ships around the world with the aid of an "astronomical ring" . . . one of the navigational wonders of his age. Hung from the steady hand of a sure-eyed seaman, readings were taken by sighting through the rings. Set for the month and day of the week, this ingenious device employed the sun's declination to first determine latitude, then the hour and finally the meridional point of the ship's position.

Today, the "sure eye and steady hand" of Arma's inertial guidance system solves the intricate problems posed by navigating in space . . . keeps space vehicles on course by sensing the most minute changes from programmed speed and direction. And, despite its precise capabilities, the sensing gyro of the guidance system is small enough to be completely encompassed within Magellan's unique brass rings.

Arma, developer of the all inertial Atlas guidance system, airborne fire-control systems, weapons systems for all Navy submarines, and pioneer in space research programs, provides industry and the defense establishment with products and systems of top reliability and value. ARMA, Garden City, New York, a division of American Bosch Arma Corporation . . . the future is our business.

"Visit us at booth 4126-4128—WESCON SHOW"

AMERICAN BOSCH ARMA CORPORATION

Otto J. M. Smith
dissident from black boxes

Prof. Otto J. M. Smith could easily pass for a sociologist, industrial economist, or authority on international relations. He has managed to escape his technical environment to contemplate some of the aesthetic aspects of life, to enrich his control studies by applying a broad human counterpoint to his technical thinking. As a result he embraces some unique viewpoints.

The 44-year-old professor of electrical engineering at the University of California has plumbed nonlinear controls. He has been an advocate of mode saturation, or the "bang-bang" control based on the research of the Russian Pontryagin, instead of proportional control. Much of his fundamental study is now being used in systems that "work at full force or not at all" in satellite attitude controls.

His current interest is formulating what he calls the Value Function Approach to continuous process control. Says Dr. Smith, "I'm examining a system's outputs in dollar value because the prime value function of any process is the dollar function. That is what an industrial user is really trying to optimize in process control."

As you might expect, the approach is radical. In contrast to what many control engineers are thinking, Smith says the engineer does not need a detailed mathematical model of a process to develop a workable optimization of a control system. Instead, he bases his approach on a calculated ignorance of the nonlinear process equation. And he claims that this kind of optimization doesn't require a computer. He says, "It's foolish to drive and store in a computer something you already have."

The UC professor uses a gas diode or a noise generator to disturb the setpoints slightly over a programmed pattern of time periods while the plant is in actual operation. Changes in the dollar output are observed and correlated with the perturbations.

Two important refinements have been added to the basic theory of input perturbation by Dr. Smith and his UC colleagues. For one, Smith adds an "identifying loop" to compensate for delays inherent in the process between perturbations and output so that the process is in phase with the perturbations. The loop can be built without any knowledge of the process since the phases can be determined automatically. And because Dr. Smith's approach works with the slope of the value curve, rather than with the best previous setting, it operates continuously, not on a sample basis.

Since Otto Smith earned his Ph.D. degree in Electrical Engineering at Stanford University in 1941, after taking a B.S. degree in E.E. and a B.S. degree in chemistry concurrently at Oklahoma A&M College, he has been a peripatetic observer of the control scene. He has already visited 30 different countries in the capacity of visiting professor, fellow, lecturer, conference delegate, or tourist. For two years, 1954 to 1956, he was visiting professor of servomechanisms at Instituto Tecnologico de Aeronautica at Sao Paulo, Brazil. Last year, for seven months, he conducted research at the Institut für Regelungstechnik, Technische Hochschule, in Darmstadt, Germany. He ended last year's stay in Europe with a forty-day camping trip through the Soviet Union.

Despite dissident thought and intensive travel, Smith has already jammed into his lifetime the equivalent of several careers. Before he joined the University of California in 1947, he taught at Tufts and at Denver University. He was a research engineer at Westinghouse Electric and chief electrical engineer for the Scranton Record Co. He is the author of the textbook, "*Feedback Control Systems*",* the inventor of a low-frequency sine function generator, an X-ray thickness gage, a constant-frequency variable-speed generator, and a controlled-torque ac motor. He has published about 50 technical papers and writes about 10 a year, many of which are presentations at technical meetings and are not published.

*McGraw-Hill Book Co., Inc., New York, N. Y., 1958.

Versatile programming

plug-in programming for each individual column, code options with plug-in column cards

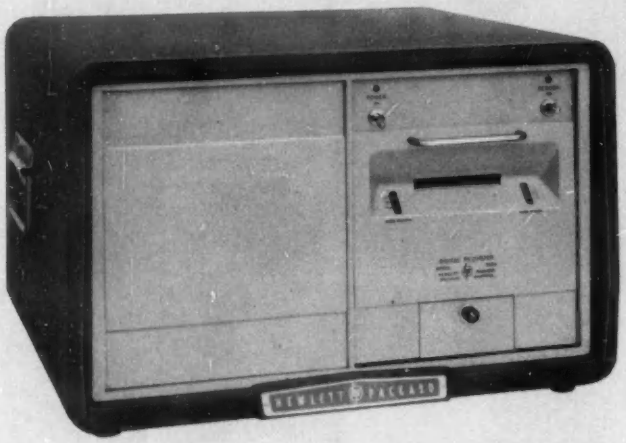
Fast data transfer

takes just 2 msec; prints up to 5 lines per second

Flexible BCD input

1-2-2-4 BCD input is standard; dual input available

all yours with this new hp 562A SOLID STATE DIGITAL RECORDER



SPECIFICATIONS

Printing Rate: 5 lines/sec. maximum

Column Capacity: To 11 columns (12 available on special order)

Print Wheels: 12-position, 0 through 9, a minus and a blank (Many special character wheels available from stock)

Driving Source: Parallel-entry 4-line BCD, 1-2-2-4. Other codes available on plug-in cards. Source reference voltages establish "0" and "1" states, which may be as much as 100 v above or below ground. "1" state 4 to 75 v above "0" reference. Driving power approx. 30 μa into 270,000 ohms.

Print Command: ± pulse, 20 μsec or greater in width, 6 to 20 v.

Hold Signal: (Available for each data source) —7 v to + 15 v and + 15 v to —7 v.

Transfer Time: 2 msec

Paper Required: Standard 3" roll or folded

Line Spacing: Single or double, adjustable

Size: Cabinet, 20¾" x 12½" x 18½"; Rack, 19" x 10½" x 16⅞" deep behind panel.

Price: hp 562A (cabinet) or hp 562AR (rack mount) $1,600.00 to $2,200.00 depending on options. hp 580A Digital-Analog Converter, price on request.

New, solid state hp 562A Digital Recorder prints digital data on 3" paper as fast as 5 lines per second, each line containing up to 12 digits. The instrument incorporates a unique data storage unit for each digit column that allows the data source to transfer data to the recorder in just 2 milliseconds, after which the source is free to collect new data.

Besides the standard parallel-entry 4-line BCD code (1-2-2-4), you can easily use other 4-line codes just by substituting plug-in column cards. Ten-line code operation (without data storage feature) is also available with plug-in cards.

Further, hp 562A accepts dual input (optional) and prints data simultaneously from two unsynchronized sources. A "patch panel" permits programming these two separate, unsynchronous inputs (even if coded differently) in any manner. Combinations of plug-in column code cards and "patch panel" column programming give complete flexibility in both dual-source data acquisition and data print positioning.

Analog output for high-resolution strip chart and X-Y recording is available as an extra-cost built-in feature of the 562A or through the new hp 580A Digital-Analog Converter, a separate solid state, high-precision instrument.

Designed for use with solid state and vacuum tube counters, Model 562A is ideal for a wide variety of individual and system applications. Call your hp representative today.

HEWLETT-PACKARD COMPANY

1082H Page Mill Road, Palo Alto, California, U.S.A.
Cable "HEWPACK", DAvenport 6-7000

Sales representatives in all principal areas

HEWLETT-PACKARD S.A.

Rue du Vieux Billard No. 1, Geneva, Switzerland
Cable "HEWPACKSA", Tel. No. (022) 26. 43. 36

7087

Newsbreaks In Control

France Gets Europe's First Automatic Steel Mill

Paris—A new steel-beam mill now being built at Hayange, France, by DeWenden et Cie, S.A., will be the first completely automatically controlled steel mill in Europe. A Westinghouse Prodac control system will direct 42 dc mill motors. Mode of control can be full automatic, semi-automatic, or manual. Scheduled completion date: late in 1962.

Data Collectors Automate Purchasing Function

Los Angeles—With the installation of Teletype data collection machines in Receiving, Inspection, and Purchasing Departments, North American Aviation's Space and Information Systems Division has virtually instantaneous control of purchasing functions. The IBM Ramac 305 (soon to be replaced by an IBM 1401) data processing system automatically issues purchase orders, emergency materiel notices, and materiel status reports. System reduced required inventory space by 20 per cent and paperwork personnel by 40 per cent.

Molecular Electronics is Closer Than You Think

Pittsburgh—Westinghouse Electric Corporation will announce commercial availability of both industrial and consumer molecular electronic products in the fall of 1962. Industrial products will include logic elements and amplifiers. Six consumer products are slated to be introduced by Westinghouse appliance dealers in the fall line. Component makers are talking about the $12 million the company will spend to develop the line.

New Electronic Process Control Line Due

New York—A new supplier of electronic process control will debut in January 1962. The company, not now in the process control field, will offer a complete line—the first controllers built of advanced solid state devices such as thin films and vacuum deposited magnetic units.

Computer To Diagnose Heart Ailments

Washington—U.S. Public Health Service will try to develop a technique to make heart disease diagnosis with a digital computer. A nine-month feasibility study showed sufficient promise that the Health Service has purchased computer time for a full scale investigation. Over the next eight to twelve months, the Service will try to analyze electrocardiograph wave forms in such a way that the results will indicate a diseased heart condition to a physician.

WILL THIS . . .

GE 312 computer now accumulates and totals data; someday it may run the plant.

. . . REPLACE THIS?

Control panel at sintering plant is designed for manual, semiautomatic, or automatic mode of operation.

Sintering Plant Doubles As Laboratory for Controls

Control engineers are learning how to apply automatic signals to a sintering plant on a full scale production model that turns out 4,200 tons of sinter per day at Youngstown Sheet and Tube.

EAST CHICAGO, IND.— Automatic control is coming to Youngstown Sheet and Tube Co.'s No. 2 sintering plant here in stages. The company claims it has already applied more automatic devices than any other operator. Eventually Youngstown expects to run its plant with closed-loop computer control.

What makes automatic control so difficult in this case is that many process relationships are unknown in sintering and a complete mathematical model of the plant still evades process engineers.

Sintering is important to the steel industry because it makes low grade ore suitable for charging into a blast furnace. Low grade ore is mined in small pieces which normally blow out of the furnace. In the sintering mill, heat bonds these small pieces into large chunks that make good feed.

First large scale application of automatic controls in plant No. 2 involved the variable speed drives applied to all the mechanisms that move material throughout the system. Then a General Electric GE 312 computer was installed to accumulate process data and convert it into averaged and totaled information. Data is collected from 89 different points; printouts can be scheduled to average data over 5, 15, 30, or 60 min periods and totals are printed for eight-hour periods.

• **Five components** – Youngstown uses the Dwight-Lloyd continuous sintering process. The first step is preparing the proper mix. The sinter is made from five components: iron ore, limestone, coke, flue dust, and recycled sinter. These are stored in 10 hoppers (five for ore, two for coke, and one each for limestone, flue dust, and recycled sinter), and each has a table feeder, driven by a variable speed drive, which regulates the flow of material onto a conveyor belt.

Flow from each hopper can be varied from zero to 50 tons per hour by changing the table feeder speed. A voltage regulator reduces load variation effects and a voltage rate feedback circuit limits motor acceleration rate.

The proportion of each material flowing into the mix is regulated by a reference signal proportional to the flow required. In the voltage regulator, the reference signal is a base excitation voltage. Any deviation from this voltage feeds back as an error signal to a controller that maintains the desired speed and thus the desired proportions of each component.

Load cells beneath each conveyor measure tons-per-hour flow as each material moves out of its hopper. This data feeds visual displays to inform the operators, the data logger for summary reports, and the feedback circuits to correct the mix.

• **Mixing**–One of the key variables in the process is the moisture content, which is added in specified amounts in a pug mill where all the ingredients are combined into a homogenous mixture. Water can't be added automatically now because there is no on-stream device capable of measuring moisture content.

Youngstown adds water manually to make the final mix 8 to 10 percent water by volume. But this method, is not accurate; it ignores any moisture already in the mix.

After it has been stirred in the pug mill, the moist mix flows to a distributor which spreads it evenly onto an endless conveyor belt called the "strand". As the mix moves past the scraper, gas flames ignite the coke in its top surface, while windboxes below the entire 168 ft of strand grate draw air through the mixture to sustain combustion. Burning fuses the mix into clinker-like chunks. Under optimum control, the strand moves at such a rate that the coke burns to the bottom of the mix bed just as it reaches the last windbox.

Strand speed is very important be-

cause burning proceeds at a fixed rate, dependent only on the porosity of the bed. Speed of the strand grate determines whether or not the system sinters the greatest volume of material in optimum time, that is, so all the coke is oxidized just before the end of the strand is reached.

Since porosity is the one factor that affects burning rate, Youngstown has installed an automatic control to regulate it. When the raw material enters the strand, the scraper blade that spreads it also dams it up, compressing the ore below it. This makes the bed denser than it should be and slows up the burning rate.

The control is simple. A series of electrical probes of different heights extend in front of the scraper blade. Measurement of the electrical resistance of material between the probes generates a signal that is proportional to the amount of material retained by the scraper. If too much material is retained the strand is speeded up. Ideally, the strand carries material away as fast as it is delivered.

As the burned sinter falls off the strand, it is broken into 8-in chunks that are the charge to the blast furnace. Undersized material, called fines, are fed back to the supply hopper as recycled sinter to become raw material again. The usable product averages about 57 percent of total raw material input.

• **Transport time**—All this processing takes considerable time. The change of a control and its effect may be as much as 30 min apart.

Stabilization thus becomes a difficult problem. General Electric engineers, who designed much of the control system, found a satisfactory transfer function—a linear first order Pade approximation—to represent the stabilizer. In hardware, it turned out to be a transistorized integrating amplifier with low feedback noise.

• **Automatic control** – At present Youngstown can operate the sintering unit manually, in a semiautomatic mode, or completely automatically.

Automatic operation ties together the feed from the hoppers and the speed of the strand. An operator chooses only the point on the strand where "burn through" (the point where the coke will be completely consumed) will occur; then the automatic control system takes over.

The point of burn through is located by scanning readings from thermocouples in each windbox. A sharp temperature drop occurs in the air passing through the windbox above which burn through has occurred. In this way the control can locate the burn through point.

As the sintering unit operates, the burn through point moves. If it recedes from the desired position, the strand has to be speeded up.

Before this is done, however, a signal to the proportioning system accelerates the table feeders under the supply hoppers so they deliver more raw material. As more mix arrives at the scraper blade, the electrical probes sense the increase in depth and generate a signal that speeds up the strand to carry away the extra material, thus moving the burn through point towards the desired point.

Conversely, the system slows the strand if burn through moves ahead of the desired point.

• **Other modes**—In manual operation, the operator sets rheostats to regulate table feeder and conveyor speeds, strand speed, and scraper height. Once set, the motors run at the established speed until the operator makes another change. To make adjustments, the operator scans a tons-per-hour reading for each table feeder and belt, the readings being brought to the big control panel shown at the top of page

Semiautomatic operation applies automatic control to the strand, but the proportioning system remains on manual regulation. Strand speed is controlled automatically; the operator sets and adjusts conveyor and feeder speeds.

• **Experiments**—Some of the most exciting control ideas are still in the design and proposal stages. For example, Youngstown is experimenting with X-ray emission gages to make on-stream chemical analysis of the mix.

If trials with the emission gages are successful, Youngstown will install five of them to analyze iron ore, coke, limestone, flue dust, and the final product. At first, information from the emission gages will only tell blast furnace operators precisely what chemical analysis to expect from the sintering plant so they can operate the blast unit at optimum conditions. Eventually, the emission gage data might be used to control proportioning in the sintering plant itself.

Youngstown is also experimenting with ways to measure moisture content automatically to control water addition at the pug mill.

So far the most promising approach is measurement of the humidity of the draft air at exhaust fan after being drawn through the sinter bed.

The steel company feels that computers can be used for control once the dynamic characteristics of sintering are known. But nobody is willing to guess when unit No. 2's computer will do something besides data accumulation and totalizing.

—Bruce Cross
McGraw-Hill News

Theory Draws Users to JACC

User engineers demonstrated an unusual amount of interest in control theory at the Joint Automatic Control Conference.

BOULDER, COLO.—Is interest in control theory mushrooming among user engineers? The answer must be yes if the June Joint Automatic Control Conference is any criteria. Of the 600 registrants, fully 270 could be classified in the user category, a startlingly high percentage. Last year's meeting, for example, was heavily dominated by academicians and researchers.

Even more interesting was the growth of process control user interest in theory. Of the 270 users, over 40 percent represented process control companies.

At the magnificent University of Colorado campus, the assemblage heard a largely disconnected review of the field. It included such diverse subjects as optimization, economics, mathematical models and adaptivity.

The accent on user interest was highlighted by two comments, neatly worded by conference participants. J. A. Aseltine, Aerospace Corp., moderator of one of the sessions on adaptive control expressed one viewpoint: He said, "I feel I've solved a lot of problems with my adaptive work, but I'm still looking for someone who needs the solution".

From Eric Weiss, Sun Oil Co., came another significant comment. He said, "The only reason chemical processes are assumed steady is that the variables are logged only once an hour. What we thought was constancy was really ignorance".

One of the objectives of the Boulder program was to examine whether adaptive systems might partially compensate for ignorance of process dynamics.

• **Language barrier**—The influx of process control engineers can be associated with the growth of computer control and both static and dynamic optimization in the process industries. Engineers working on Aerospace projects have solved some of these problems. University and maker theoreticians have offered some others. JACC looms as a common ground for trading information and experience.

User after user moaned "We can't tell whether we'll ever be able to apply these techniques or not unless we can find some way of understanding what the mathematicians are driving at in physical terms".

Russian Science Stalls; The Soviets Reorganize

Complete reorganization of Soviet scientific effort has been ordered. Soviets voice concern about costs as R&D expenditures top 3.8 billion rubles and head higher.

MOSCOW—

Soviet planners are not satisfied with the results from the USSR's gigantic scientific effort. Because output is not keeping up with spiraling costs, the USSR is making a major overhaul of its scientific research and development. One casualty may be the "pure" researcher who can't justify his work to hardheaded planners. And there's likely to be a new slant on control development.

Some details of the reorganization were outlined at last month's All Union Conference of Scientific Workers in Moscow. As expected, two thousand assembled scientists "unanimously" endorsed the government's decision and put major responsibility for scientific planning in the hands of a new state committee for coordination of scientific research. The move will trim some fat from the USSR's Academy of Sciences.

• **What's wrong**—After listening to a tabulation of Soviet scientific successes—such as rocketry and space accomplishments, discovery of new oil and natural gas deposits, and research in the use of oxygen blowing in steel production—participants heard some unusually frank talk about what's wrong.

Some shortcomings:

• Last year's plan called for introduction of new technology in 891 projects—only 64 percent were completed and ten weren't even begun.

• In 1954, Academy of Science researchers evolved a new way to use semiconductor devices as nonlinear capacitors. Russia started working on improvement of these instruments only after the foreign press reported their use in parameter amplifiers. It is an indication, say Russian critics, that there is a serious lag in research on semiconductors.

• Introduction of automation has been retarded because of lack of coordination between designers of plants, machinery, and automatic control systems (a complaint repeated almost annually).

• Duplication is running rampant. For example, in Russia, 100 organizations are doing research on direct conversion of heat into electric power. One hundred and fifty establishments are designing digital programming control systems for automation of machines and installations. But most are directing their main attention to designing computers which differ only slightly, not to creating new systems.

• Scientific instruments are often scarce and unreliable.

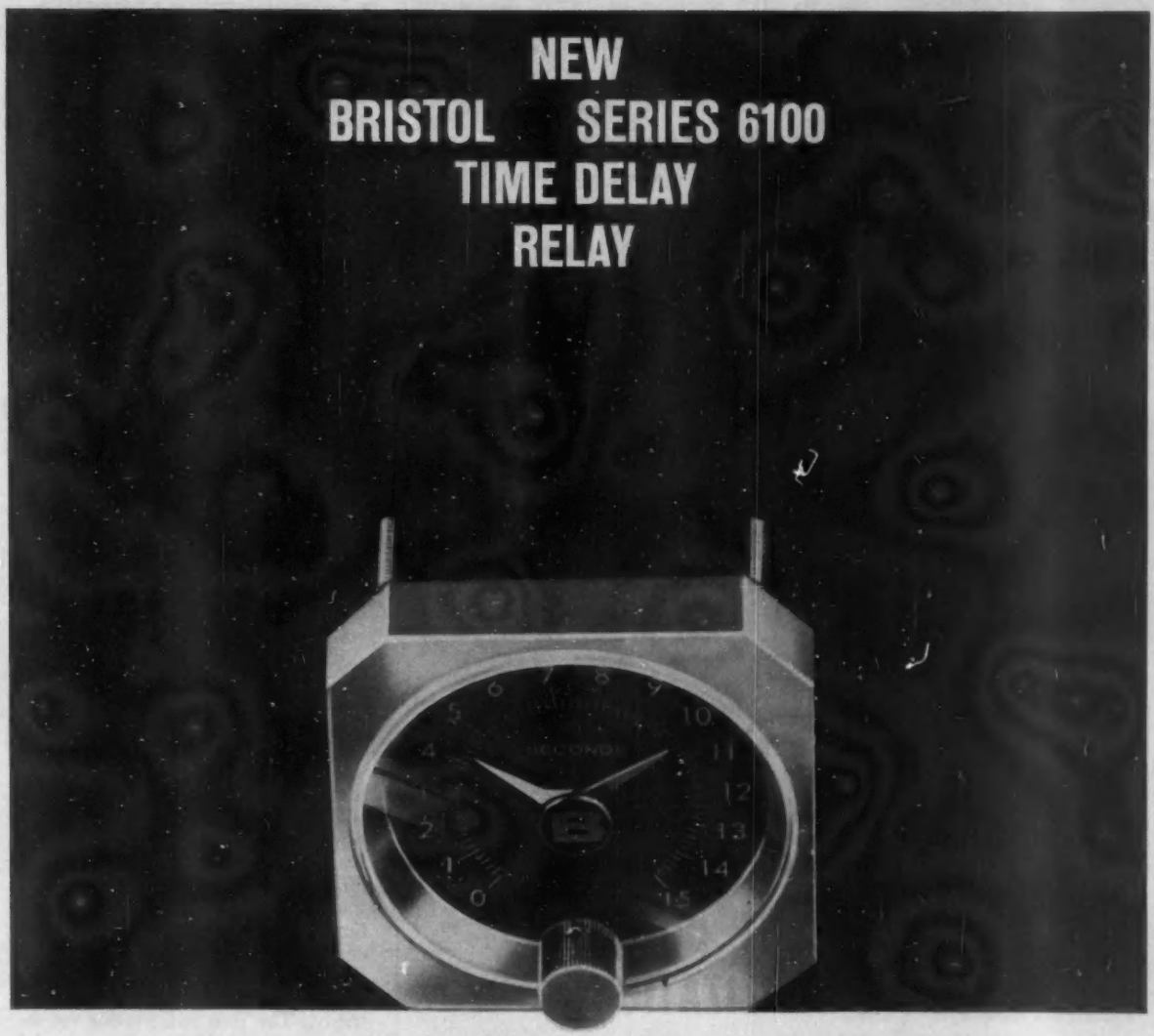
The big problems add up to the same woe that has plagued the Soviets for years: duplication and lack of cooperation between scientists working on related problems. Worst of all from the Russian standpoint, the lag in putting scientific discoveries to work in production persists.

The new Soviet reorganization plan spotlighted at least one problem that is being admitted for the first time: the Russians are having trouble selecting and training young scientists and then integrating them into the main stream of research work.

• **Manpower stumbles**—M. V. Keldysh, new president of the Academy of Sciences, notes that half the 4,000 scientists receiving doctorates in the past ten years were more than 50 years old. He called for measures to promote training of scientists between 30 to 35 years old for independent scientific work. One Soviet scientist, although criticizing the "insecurity" of young American scientists as they compete for permanent niches during the years after graduation, commented wistfully that "those fortunate ones who strike it lucky acquire excellent if severe schooling during their years of wandering."

Recruiting is a problem too, speakers conceded. Despite widely heralded educational opportunities in the Soviet Union, science students are harvested almost entirely from a very limited

NEW BRISTOL SERIES 6100 TIME DELAY RELAY



7 TYPES OF LOAD CIRCUIT OPERATION ALL IN A SINGLE UNIT

Bristol's new Series 6100 gives you easy application with exclusive flexibility. No more complex wiring changes! Make circuit changes in a jiffy, too. You can reach the motor, and other parts—in seconds. The new "Bristol-Vision" dial is mounted in a square die-cast frame—provides better contrast for better viewing plus functional beauty too. Non-scratch bevelled *glass* dial cover won't buckle, deform—seals against dust. Powered by famous duty-matched standard Bristol motor. Write for brochure.

Contact the Bristol Distributor or Representative in your area.

SEND FOR HANDY TIMING CONTROL PRODUCT DIGEST —complete range of Bristol Motors, Timers and Timing Devices for all your timing and control applications.

LEADING SPECIALISTS IN AC AND DC MOTORS — from standard to special configurations designed to your specifications.

BRISTOL MOTORS *Division of Vocaline Company of America, Inc. / Old Saybrook, Conn.*

WHAT'S NEW

geographic area. A boy living in Siberia, for example, is eligible but unlikely to become a physicist because "he isn't even aware of the existence of the new physics".

Still another failing is the low quality of scientific research. Once admitted to research institutes, scientists are kept for years even though they do not have the capacity for independent work, thus shutting out better qualified men.

• **Drastic steps**—To solve these weaknesses, the USSR has taken a number of steps. First was the appointment of Keldysh to succeed A. N. Nesneyanov as head of the Academy of Sciences. Then, several weeks ago, the Kremlin announced the abolition of the state scientific and technical committee, which used to have much of the responsibility for introducing new technology. In its place, a new state committee for coordination of scientific research was organized.

• **Starting over**—The new approach for a unified state plan of scientific research will include three stages of research:

• Major national economic problems which are in the experimental design stage—such as automation systems, polymer applications, gas turbines, and new metals and alloys. The plan will assign tasks for implementation right through introduction into practice.

• Long range scientific investigations into key problems that are far enough along to be defined—such as thermonuclear fusion research and direct transformation of heat into electricity. The plan will provide for research work, designs, and creation of experimental installations. But this stage won't reach the factory level.

• Fundamental research, whose correct channeling will be "dictated by logic of scientific development". Even though the Academy of Sciences itself apparently will continue both fundamental and applied research, it will turn over half of its research institutes to industry, and concentrate on solving key scientific tasks.

Short term research planning is out, according to Deputy Premier Alexei Kosygin. "Research projects should be planned to cover the whole period until their completion", with material and financial support to match.

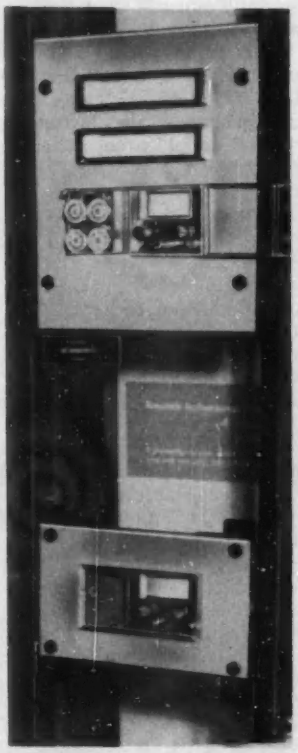
Keldysh has earmarked a number of key projects for academy units. In the control field, for example: self-adapting control systems, and computer application to information storage and economic planning.

—Ernest Conine
McGraw-Hill World News

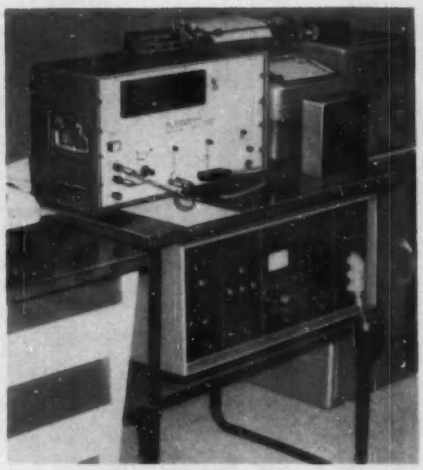
EUROPEAN REPORT

Highlights at ACHEMA

100,000 visitors search the triennal ACHEMA chemical engineering show for new developments in control. Europe's spreading labor shortage heightens interest in automatic control. Demand for process instrumentation still outstrips supply in Europe.



Pneumatic four-term controller contains extra integral action. Supplier was G.S.T. of Bochum.



Easy-to-use infrared analyzer with analog computer was displayed by Bodenseewerk Perkin-Elmer & Co.

FRANKFURT, GERMANY—Crowds flocked to the German ACHEMA chemical engineering exhibition this year with an interest in control whetted by growing economic concern: a labor shortage is spreading in Europe. Said one control manufacturer, "The labor shortage is turning some companies to automatic controls for the first time. And the increased sales are snarling up production schedules even worse than they have been."

Delivery still remains European control manufacturers' number one problem. Delivery of standard controllers and recorders, for example, takes 12 months. As a result, control manufacturers have almost as much interest in laborsaving production equipment as their customers.

Certainly the emphasis at this year's show was on easy-to-use equipment. One company, Bodenseewerk Perkin-Elmer & Co., showed 10 new products, all reflecting a philosophy of operating simplicity. In one, the company added an analog computer to an infrared spectrometer so the instrument would calculate the percentage concentration of each of six components directly. Previously, an operator would read the device and then calculate the percentage. Here is how it works. A potentiometer matrix sends the extinction point for each component of the substance into the computer every three min so it can solve five basic equations for the wave lengths selected.

Another easy-to-use instrument was PE's new autopolarimeter with digital readout. All the operator has to do is insert samples into the instrument. A polarized light beam that oscillates 7 deg on either side of the optical axis illuminates the sample. A photomultiplier detects the beam and drives a null balancing servo to rotate an analyzer prism. The rotation is read out on a digital counter.

• **Automatic petroleum testing**—Pet-

WHAT'S NEW

roleum companies too want more automatic devices. Baird & Tatlock Ltd., an English company that invaded Germany for the show, has an instrument to determine the oil base content automatically to the requirements of ASTM D664 specifications. Mechanical carriers in the instrument bring the oil sample to an automatic titrator.

Punched cards attached to the carrier program the B&T instrument for weight of sample and test to be run, then select the proper one of five burettes containing different solutions. For the test, the sample beaker is carried to an electrode set and the sample is titrated. Print wheels record the endpoint pH value on the carrier card.

An Italian company, Carlo Erba of Milan, has a new instrument that determines the flash point of oil automatically. In this device, samples feed to an explosion chamber every three min. At input, the samples are cooled to about 15 deg below the flash point. Then the sample is heated and air added until a sparkplug ignites the air-vapor mixture. A flash detector stops the heating cycle while a thermocouple in the heated liquid measures the flash temperature.

• **New controllers**—At least three new control systems were introduced at the show. A pneumatic four-term controller, shown by the German firm G.S.T., generated the most interest. An extra integral action is added to the normal three-term action. The company claims this allows the proportional range to be extended ten times. Range of the G.S.T. controller: from 2 to 1,000 percent.

Discussions with visitors and exhibitors indicated that application of digital control is growing in Europe. Its strongest advocate is Siemens, which is using digital methods for tank gaging, motor synchronization, and gas chromatograph recording.

The motor synchronization control has Hall generator pickoffs that send speed signals to each of three motors. One output serves as the master control. It sets the overflow limits of two digital registers so that overflow pulses, which control the slave motors, always occur at a set phase angle.

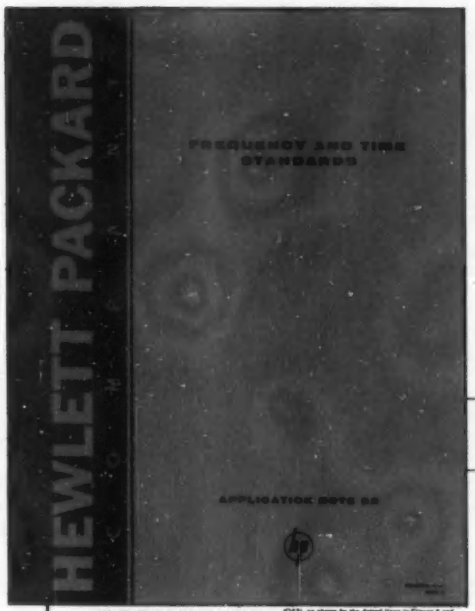
Despite some damp German weather, over 100,000 visitors toured ACHEMA during its nine-day run. This attendance, together with the 70,000 who attended the French measurement show Mesucora, (CtE, July, p. 29) testifies that European interest in automatic control has not slowed.

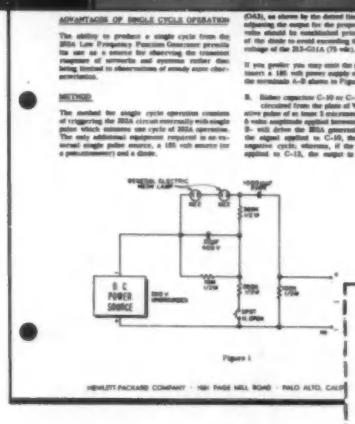
—Derek Barlow

Get valuable information on advanced measuring techniques

APPLICATION NOTES

yours without charge, without obligation





Hewlett-Packard Application Notes, covering a wide variety of subjects, include both theoretical and "how to do it" information. They are composed of information derived from the experience of hp engineers both in general areas of measurement and in solving specific measurement problems. Many interested readers have found Application Notes useful in the past. You may find them helpful, too.

Check this partial list of titles:

- # 2 Frequency Measurement of Low-Level Signals, up to and above 12.4 GC
- # 6 Homodyne Generator Detection System, to measure attenuation, rf leakage, antenna patterns, etc.
- #15 Distortion and Intermodulation
- #36 Sampling Oscillography
- #42 Applications of 416A Ratio Meter, reflectometer techniques
- #43 Continuous Monitoring of Radar Noise Figures
- #44 Use and Usefulness of the 185A 1,000 MC Oscilloscope (44A, Synchronizing the 185A; 44B, Pulse Analysis; 44C, Component Switching Speed Characteristics Measurement)
- #48 Applications of the 218A Pulse and Delay Generator
- #50 How to Make VLF Frequency Comparison Measurements with Standard Laboratory Equipment
- #52 Frequency and Time Standards

Other Application Notes cover such subjects as measuring FM signals, measuring rf pulse carrier frequency, microwave spectrum synthesis, waves on transmission lines, square wave and pulse testing, measurement of cable characteristics, instruments for transducer applications. The Application Notes Index gives a complete listing.

Fill in and mail the attached post card for Application Notes of interest to you, or for a complete list of titles.

See the reverse side of this page for other helpful hp publications

First Class
Permit No. 201
Palo Alto, Calif.

BUSINESS REPLY MAIL
No postage stamp necessary if mailed in U. S.

—Postage Will Be Paid By—

Hewlett-Packard Company
Department H
1501 Page Mill Road
Palo Alto, California

Engineers in electronics and allied fields are invited to join the roster of regular readers of the hp JOURNAL published throughout the year, presenting factual reports on new measurement techniques, new instrumentation.

TYPICAL SUBJECTS

- Improved sweep frequency techniques for broad band microwave testing
- Square wave and pulse testing of linear systems
- Effect of μ-circuit non-linearity on the amplitude stability of RC oscillators
- A new frequency counter plug-in unit for direct frequency measurement to 510 MC
- Two versatile new power supplies for high power semiconductor work
- An improved method for measuring losses in short waveguide lengths

YOURS WITHOUT CHARGE *Just check box in white area on card below and mail.*

Please send these APPLICATION NOTES:

☐ #2, ☐ #6, ☐ #15, ☐ #36, ☐ #42, ☐ #43, ☐ #44A, ☐ #44B,

☐ #44C, ☐ #48, ☐ #50, ☐ #52, ☐ Complete Index

☐ Put me on the mailing list for the hp JOURNAL

☐ Inform my hp representative that I would like to receive the new 1961 hp general catalog.

Name _____ Title _____

Company _____ Bldg. or Mail Sta. _____

Address _____

City _____ Zone _____ State _____

Now available! The new 1961 hp catalog giving complete information on the more than 400 precision electronic instruments manufactured by Hewlett-Packard. Just contact your nearest hp representative for your copy — or check the appropriate box on the postcard.

WHAT'S NEW

IMEKO: How to Estimate a Planned Economy

Hungarian measurement meeting gives Western observers a new slant on Iron Curtain control problems.

BUDAPEST—

At IMEKO, the Second International Measurement Conference, most papers stressed specific applications of instruments rather than new techniques or philosophy. As a result, interest in any one paper was limited to those working in the same area.

One problem of Eastern bloc countries that intrigued many Western visitors is the way Communist countries approach the business of planning instrument production.

Dr. H. Kortum of East Germany described the task of production planning. He said that predicting what should be done is complicated by the increase in instrument variety and the growing requirements for better quality. Kortum urged the establishment of a special group to develop production estimating.

Dr. Gy Striker of Hungary maintained that data are available for such an estimation. He named two possible sources: an index of instrumentation, which is the ratio of instrument investment to total investment, and estimated capital investments.

• **Technical highlights**—The conference, heard 138 papers, covering a variety of areas. Some highlights:

► Strain gage replaces slide wire in an automatic self-balancing potentiometer. The approach is similar to that announced by Minneapolis-Honeywell earlier this year. The Hungarian device is called Tensokomp.

► Two designs for low cost analog-to-digital data converters for application in power stations. Developed by a Rumanian engineer, one unit is electromechanical, other transistorized.

► **Poland's A. Macura** described a way to use magnetic fields to measure the wear of pipelines carrying abrasive fluids. He added two electromagnets to set up an undisturbed field between two base magnets.

Although no startling developments or announcements came from the conference, a resolution was passed making IMEKO a permanent international body. The conference will again be held in Hungary some time in 1964.

Fred H. Baer
McGraw-Hill World News.

Will EAI-Phillips Pact Boom Analog Computing-Control?

Analog computing-control for the process industries may soon start booming. An agreement just signed by Phillips Petroleum Co. and Electronic Associates, Inc. calls for an unusual exchange of views, ideas, and information between the user and the maker in the application of special purpose analog computers to process control. The pact mates two strong advocates of the analog approach.

It is no secret that Electronic Associates, the biggest maker of analog computers for simulation, has aspirations in process control. But EAI has been unable to dent the control market because it lacked chemical process know-how and its equipment has been designed for the laboratory and engineering department.

Control engineers at Phillips have championed the special purpose analog computer. Several years ago the company was experimenting with a special purpose computer to control internal reflux in a fractionator.

EAI expects the exchange will educate its engineers in some of the problems of the process engineer and should point the way to a flock of new products. Phillips, on the other hand, feels it will be on the receiving end of some new ideas about computer technology and hardware.

The duo have put together some ground rules to get the exchange working effectively. For example, meetings between key people in each company are scheduled at regular intervals. And each company has agreed to underwrite the expenses for its part of any undertaking.

Under the exchange agreement the rights of each company in its inventions are protected before disclosure to the other; neither firm receives any interest or license rights in the patents of the other, and each party has the unrestricted right to grant licenses under its own patents.

To speed its jump into analog computing-control hardware, EAI has already taken a license under three inventions developed by Phillips before the exchange agreement was consummated: an internal reflux computer for fractionators, a computer that regulates the enthalpy of fractionator column feed, and a product separation computer for fractionators. All that remains now is a big marketing push on behalf of analog computing-control.

Japanese Plan Overseas Instrument Service Centers

TOKYO—

Japan's Industrial Measuring Instrument Industry Association is making plans to provide a service arrangement overseas for its member firms' products. Plans are still tentative, mainly because the association hasn't solved the problem of financing the venture. Association managing director, Tetsuo Horiguchi, told CtE that "It will take a year or so before we can go ahead with plans."

Reason for the service project emerges from a glance at Japanese instrument import and export figures for the past two years. In 1959 Japan imported $10.3 million worth of measuring instruments, and exported $500,000 worth. Last year they imported only $6.9 million, exported $2.6 million. (Note that the total was off $1.3 million.) Japanese instrument makers feel that better availability of service in the overseas markets would boom sales.

The association has not decided where it will set up its first service center, but since $500,000 of 1960 exports went to the U.S., first efforts will probably be aimed at this market. In fact, Horiguchi feels, "It would be cheaper to tie up with some U.S. firms to service our machines and instruments. So far none of the U.S. firms has approached us with proposals for possible tieups. We welcome such proposals, but we need a little more time to create interest among our own people here to raise enough funds to start. Otherwise, it would be a flop."

The association did not say whether it expects U.S. firms to be as anxious to service Japanese instruments on their home ground as they were to set up sales-service combines in Japan.

—John Yamaguchi
McGraw-Hill World News

EMI Aims for Exports

LONDON—

British government officials have been urging industry here to increase its exports. While $53 million of British instrument and control goods

NEW—MINCOM SERIES G-100 RECORDER/REPRODUCER

Series G-100 Frequency Response
Direct: 200 cps to 300 kc at 60 ips
FM (extended): DC to 20 kc at 60 ips
FM (standard): DC to 10 kc at 60 ips

Building-block construction; card system record/reproduce modules; just twelve moving parts with four easy adjustments; complete plug-in modular design—everything about this new and outstanding Mincom Series G-100 emphasizes its reliable simplicity. Here's an all-purpose magnetic tape system for better performance with improved dynamic range. It's planned for easier operation and maintenance with automatic bias and power supply protection; built-in calibration, plus built-in monitor switching; dynamic braking; all-transistorized electronics; fourteen tracks (analog or FM) in one rack. Covering the bandwidths listed at right, G-100 fills the gap between Mincom's Series CA-100 (125 kc-60 ips) and the Series CM-100 (1.2 mc-120 ips). To discover more of this new system's extra capabilities, write today for complete specifications. See us at WESCON, Booth 1806.

3M COMPANY ... WHERE RESEARCH IS THE KEY TO TOMORROW

MINCOM DIVISION MINNESOTA MINING AND MANUFACTURING COMPANY

2049 SO. BARRINGTON AVE., LOS ANGELES 25, CALIFORNIA • 529 PENN BLDG., 425 13th STREET N.W., WASHINGTON 4, D.C.

WHAT'S NEW

were sent abroad last year—an 18 percent increase over 1959 (see CtE, May '61, p. 186 for more figures)—government leaders feel more can be done. They say that U.K. companies tend to ignore overseas markets because they anticipate problems of language, low volume, and different standards. One company that is taking the government's advice to heart is EMI Electronics Ltd., which has jumped its export sales from zero to $7.5 million in three years.

EMI plans eventually to reach a 60 to 40 export to domestic sales ratio; the current ratio is just the reverse. The company's export expansion program is three-pronged: 1) make the export program so large that it has to be concentrated on throughout the firm, 2) run company-sponsored language courses, and 3) set up a special export promotion department, including overseas traveling exhibits.

The program started in 1958 with a pitch to increase European sales. EMI set up language courses run partly on company time, and within two years 80 percent of the sales engineers could speak a second language.

• **Shock treatment**—"The payoff," says EMI marketing director, Robin Addie, "came within the first year. We got the order when a customer was amazed to hear a British sales engineer speak French so fluently."

The scurry by most British companies to avoid the tariff penalties built into the two European trade blocs found many firms setting up new plants within one of the areas. EMI took a different tack: it set out to so expand its export market that it could sell at prices comparable to those of goods produced on local equipment. This would be done without investing in new facilities.

• **U.S. attack**—To sell America, EMI took two approaches, both through established firms. It signed an agreement with Fairbanks, Morse & Co. to sell equipment in the U.S., and within the first seven months orders from FM totaled over $1 million. EMI also used its subsidiary Capital Records, Inc. with its acquired Hoffman Electronic Tube Co., Inc. and Voi-Shan Electronics Div. of Voi-Shan Industries. Goal for the U.S. market is to beat European sales within three years.

Next step, says Addie, is to tap what he calls the biggest potential area yet: the east European states. Campaigns have already been started in Poland, Hungary, and Russia. —**Derek Barlow**

(*More Business News on page 140*)

A NEW ADDITION TO THE SONAC LINE

POSITIVE ULTRASONIC LEVEL CONTROL

The components of Sonac (sensor actual Size)

Now, two new ultrasonic sensors, especially for level control have been added to the Delavan line of SONAC sensing and switching devices.

The single sensor system is recommended for liquid level control and the double sensor system for dry level control.

Control is maintained by installing the SONAC sensor through the wall of the vat, bin or hopper. When the oscillation on the face of the sensor is dampened or impeded by the material being sensed, the signal to the control unit changes, activating a relay.

FIG. 1—LIQUID LEVEL (One Sensor)

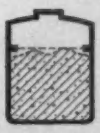


FIG. 2—DRY LEVEL (Two Sensors)

For level control, SONAC is accurate to .005" and has a response time of 25 milliseconds. Performance of the sensor does not deteriorate with age.

The level control uses to which SONAC can be applied are virtually unlimited. It is not affected by the viscosity*, specific gravity, conductivity, or capacitance of the material being sensed. Temperature or pressure changes of the material do not alter its performance. False signals are eliminated because SONAC may be adjusted so as not to sense steam, foam, or vapors.

*Viscosity may affect response time.

Canadian Representative:

KNOWLES & FOSTER (North America) Ltd.

708 Terminal Bldg., Toronto 1, Ontario, Canada

A

SONAC is extremely rugged. Sensors are type 304 stainless steel. The electronic components in the sensors are hermetically sealed and will withstand pressures to 2000 psi and temperatures from −425° F. to +450° F. They are immune to shock, vibration or mechanical damage.

The control is a compact unit 5" x 5" x 5" and features transistor circuitry. Power consumption is one watt and the unit will operate in temperature ranges from 40° F. to 135° F.

Here's how SONAC can be used for sensing and switching applications other than level control.

Automatic Counting Positioning

Door Control Package Routing

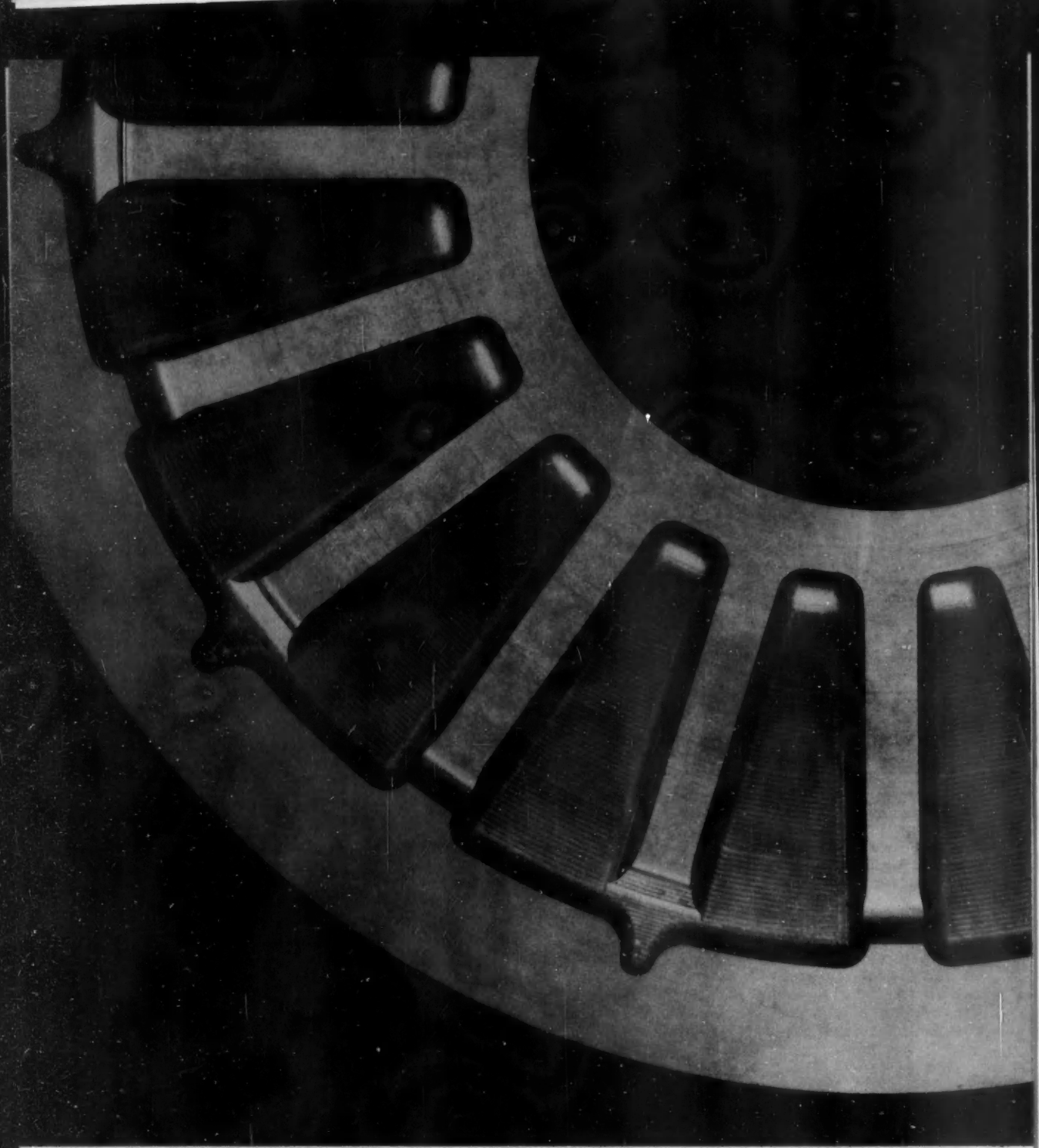
Overheight Signal Size Control

There are dozens of applications for SONAC single and double sensor units. Let it go to work for you now, write:

DELAVAN Manufacturing Company

WEST DES MOINES, IOWA

CIRCLE 39 ON READER SERVICE CARD

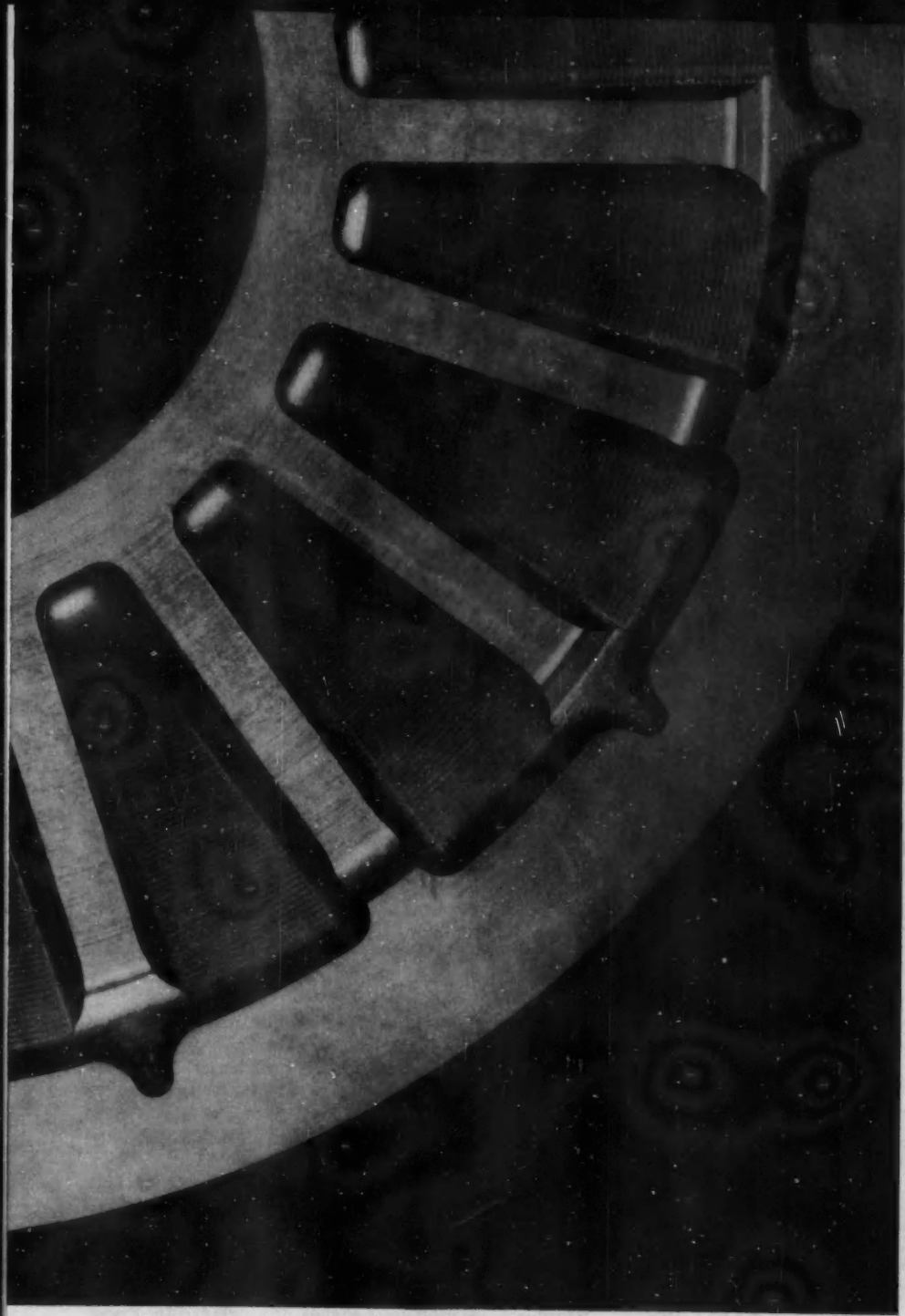


New IBM computer language...AUTOPROMT cuts milling time for this helicopter gearbox cover by 75%

AUTOPROMT (AUTOmatic PROgramming for Machine Tools) is a powerful new computer language designed to broaden the use of numerically-controlled machine tools.

AUTOPROMT, for the first time, lets an engineer *describe the surfaces* of the three-dimensional shape he wants milled, *rather than calculating every path* the tool must follow in order to machine the part.

AUTOPROMT leaves to the computer the task of automatically generating these tool paths. You describe the part to be milled and the tool to be used in simple, *English-like*



terms. The computer does the laborious calculating work.

AUTOPROMT produces results like these: the time to mill the gearbox shown in the photographs cut to *one-fourth* the machine time required by conventional methods. AUTOPROMT reduced the lead time from blueprint to production *from three months to two weeks.*

AUTOPROMT is available to IBM customers. Call your local IBM Representative for complete details on this latest advance in Numerical Control of machine tools.

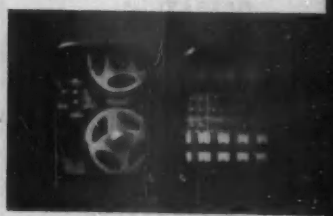
IBM®
DATA PROCESSING

Here's the way AUTOPROMT works at United Aircraft Corporation

The Parts Programmer, using a conventional blueprint, prepares 180 one-line statements in AUTOPROMT language.

The statements are punched into standard IBM cards and entered into the IBM 7090 Data Processing System. (AUTOPROMT also works with the 704 and 709 Systems).

The 7090, programmed with AUTOPROMT, produces 8000 tool path instructions needed to direct the Pratt and Whitney Co. Inc. Numeric-Keller Continuous Path Milling Machine.



Punched tapes direct the Numeric-Keller Milling Machine.

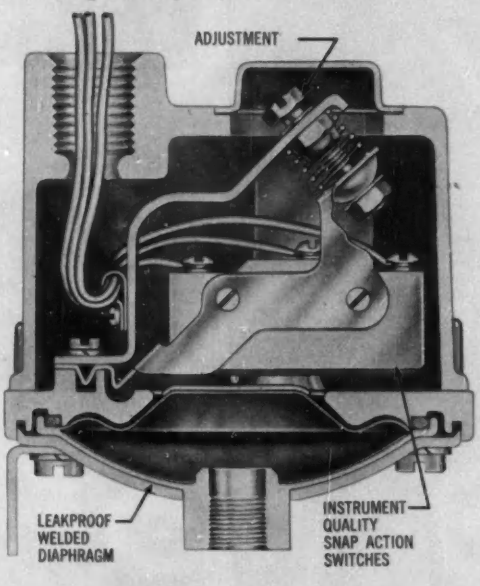
The Numeric-Keller mills the helicopter gearbox cover.

CIRCLE 41 ON READER SERVICE CARD

BREAKTHROUGH IN PRESSURE SWITCH ACCURACY

at reduced prices

The high accuracy associated with instruments costing several hundred dollars is now obtainable with new Barksdale pressure switches at a retail cost of $19.00 to $30.00. Accuracy of ±1/2% is guaranteed and ±2/10% accuracy can be supplied when required. Substantial price reduction is accomplished by use of erector set design and a major investment in production tooling. A wide choice of "tailored to the job" features (see column at right) meets your specification requirements exactly.



THESE POINTS ARE IMPORTANT

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	LINKAGES & BEARINGS which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

PRESSURE SWITCH DIVISION

Barksdale valves

5125 Alcoa Avenue, Los Angeles 58, California

New line of Barksdale pressure switches announced

Improved accuracy, reduced cost and higher proof pressures are advantages made possible by design innovations in the new Barksdale diaphragm pressure switches. Accuracy of ± ½% as compared to the customary ± 1% is guaranteed, and each unit is tested for repeat accuracy of set point and re-set point before shipment. Accuracies of ± 2/10% are available on request.

Erector set design offers dual benefit

The basic unit of all Barksdale diaphragm pressure switches is a diaphragm surrounded by a heavy protective capsule to which components may be attached as required. Addition of a switch, switch bracket and adjusting bracket to the basic unit makes a stripped switch for use in a common cabinet with other electrical devices. (Original equipment manufacturers need not pay for a housing which is not needed.) Addition of a sealed housing to the stripped switch completes a weather- and vapor-tight switch unit. A standard housing with integral terminal block or an explosion proof housing with integral terminal block may be specified. Erector set construction allows a wide choice in specifications that approximates a custom made switch and permits use of cost-cutting mass production methods that are reflected in lower prices.

Proof pressures to 300 psi

In the low settings the new Barksdale pressure switches will actuate at 0.1" mercury with proof pressure to 10 psi. In higher ranges they will go up to 300 psi proof pressure at settings to 150 psi.

Important additional advantages

Because the housings of Barksdale pressure switches are independent of the sensing and switching mechanisms changes in ambient temperature will not throw these switches out of adjustment.

The adjustment brackets are specially designed to protect switch terminals against shorting during adjustment.

Lead wires are held down by a tension clip. They cannot be pulled out accidentally and thereby throw off the switch adjustment.

Mounting brackets may be oriented in any of four directions.

Tamper proof adjustment covers have servicing instructions on the inside to allow for painting of the units.

Standard pressure connection is ¼" npt female pipe fitting. One-half inch fittings suitable for mounting directly on ½" pipe can be supplied on request.

Standard housing has ½" nps conduit connections and a terminal block. The latter is accessible without removing the housing by lifting a cover plate.

Ask for new catalog and handbook

Complete details on Barksdale diaphragm, piston and bourdon tube pressure switches are included in a new catalog and handbook. This free book is a practical aid in planning the vital link between your electric and hydraulic circuits. It contains a glossary of terms, a schematic demonstration of operating characteristics, and a suggested step-by-step procedure for simplifying pressure switch selection. In addition, the book gives a complete run-down on all the detail features leading to the unit that answers your specific control problems. Send for your copy now, or ask your Barksdale representative.

New! Sylvania CT4251

First

Compact
Decade Counter Tube
in Dome-Shaped T-9 Bulb
with 10 Output Cathodes

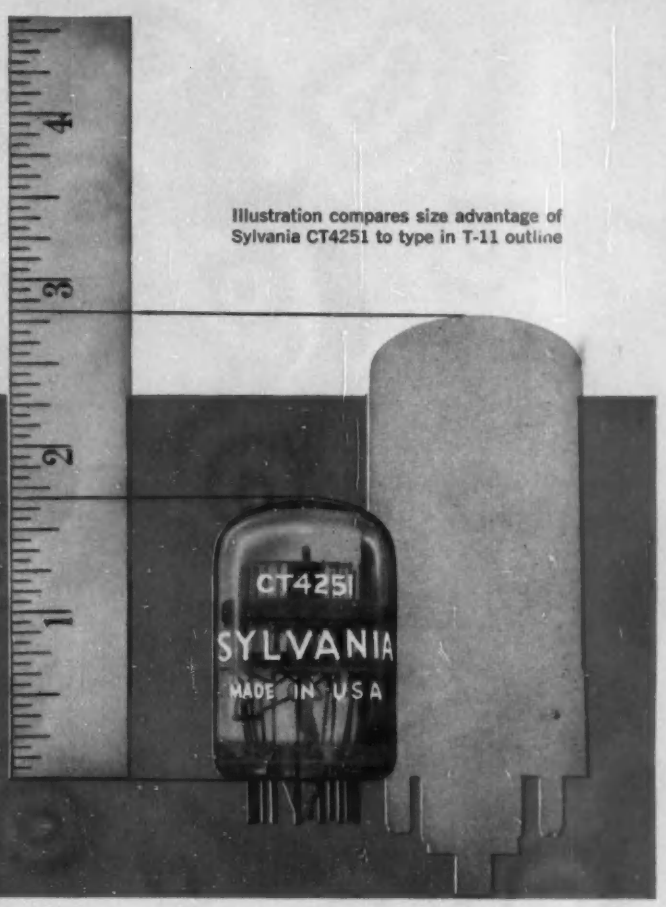


Illustration compares size advantage of Sylvania CT4251 to type in T-11 outline

Sylvania introduces the new CT4251 . . . opening a dramatic new approach to the design of very compact, low-cost counting equipment in the 0-50KC frequency range.

Utilizing a new dome-shaped T-9 bulb evacuated from the base, Sylvania CT4251 offers significant reductions in seated height. CT4251 features 10 output cathodes, offering the versatility and advantages of tube types previously available only in the T-11 bulb. Examples: electrical information can be fed from all 10 cathodes, enabling preselection of a count from 0-9; the diameter of the ring of cathodes is identical with that of types in the T-11 outline, providing excellent visibility of readout information.

Sylvania CT4251 is the lowest cost *cold cathode Decade Counter Tube* available. Combining electrical and visual readout functions, it offers extensive economies in circuitry and associated components. Sockets, too, for its 13-pin circle are as much as one-half the cost of sockets normally required for T-11 types. In addition, this new 13-pin circle makes it possible for Sylvania CT4251 to be designed into equipment using transistorized and printed circuit techniques.

Tests to date of Sylvania CT4251 indicate superior quality performance even under stand-by operation for 500 hours.

Your Sylvania Sales Engineer will be pleased to tell you more. Contact him or write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. 138, 1100 Main St., Buffalo 9, N. Y.

Sylvania Type	Total Anode Current (mA)		Min. Anode Supply Voltage (Vdc)	Min. Double Pulse Amplitude (V)	Min. Double Pulse Width (μsec)
	Min.	Max.			
CT4251	0.65	0.8	400	–70	4

SYLVANIA

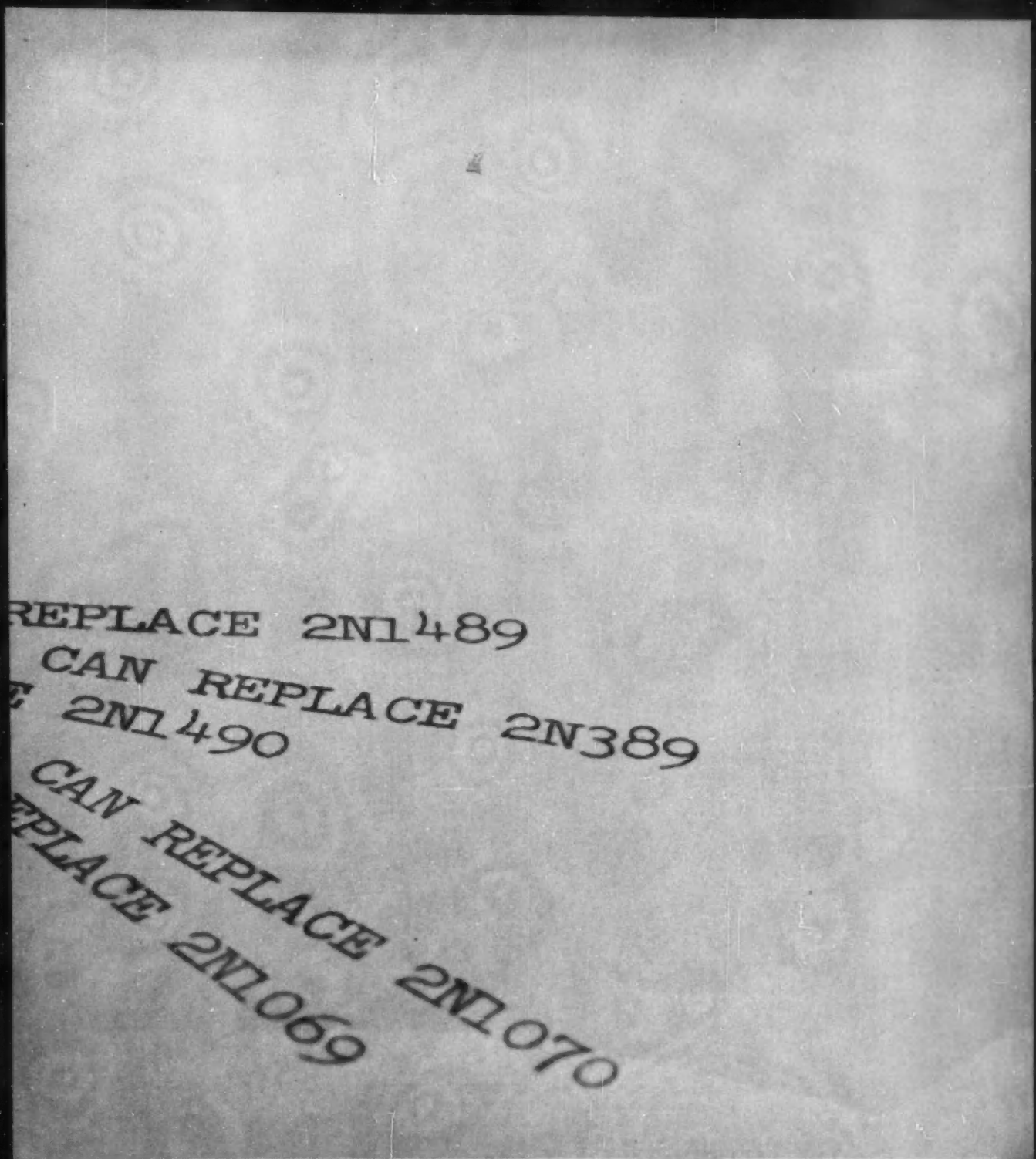
SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

greater derating margin for higher reliability...at lower cost than lower rated types

Westinghouse 2N1015 and 2N1016 transistors— Circuits which use power transistors can be upgraded in reliability by changing to the Westinghouse 2N1015-2N1016 series. The low saturation resistance and high dissipation rating (150 watts) of these transistors mean cooler operation—more safety factor in service. In fact, the 2N1015-2N1016 series offers twice the derating margin you can get in competitive types. Their high voltage ratings—up to 200 volts V_{CE}—also mean an end to series connections of lower rated types. Yet all this is yours at less cost than you are now paying.

In addition to these many circuit advantages, the 2N1015-2N1016 transistors give you the reliability assurance of



True Voltage Ratings verified by 100% Power Testing under full operating conditions. You also get the advantages of reduced inventory, and the convenience of single-source purchasing. Next time you buy transistors in the 2N1015-2N1016 family make sure they're 100% power tested. You can be sure . . . if it's Westinghouse. For complete information, write or call: Westinghouse Electric Corp., Semiconductor Dept., Youngwood, Penna.

SC-1042

Westinghouse

CIRCLE 45 ON READER SERVICE CARD

For "off the shelf" delivery, order from these Westinghouse Distributors:

EASTERN

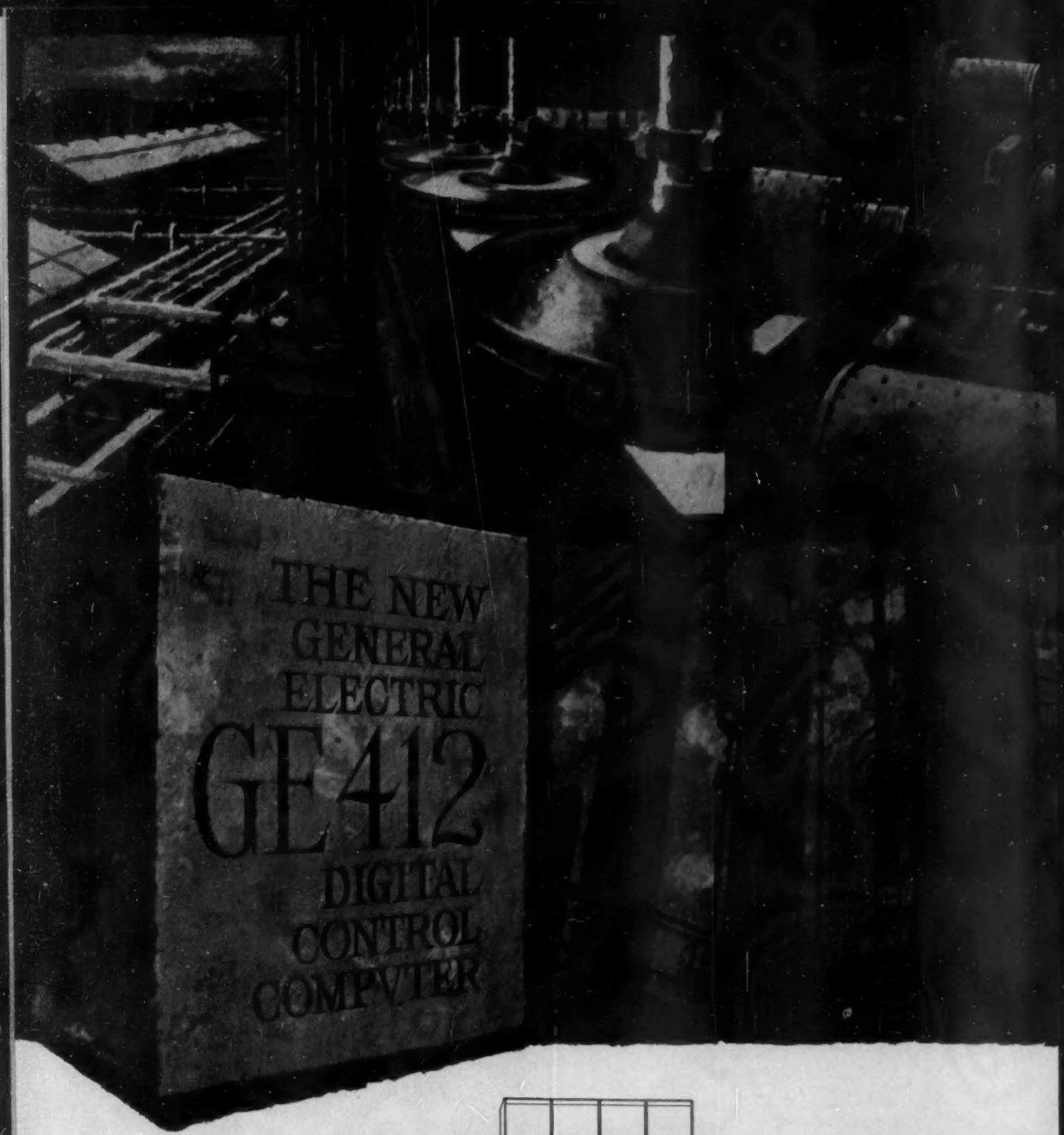
ACK SEMICONDUCTOR, INC. Birmingham 5, Ala./TA 2-0588
CAMERADIO Pittsburgh, Pa./EX 1-4000
CRAMER ELECTRONICS, INC. Boston, Mass./CO 7-4700
ELECTRONIC WHOLESALERS, INC. Melbourne, Florida/PA 3-1441
GENERAL RADIO SUPPLY CO., INC. Camden, N.J./WO 4-8560
GENESEE RADIO PTS. CO. Buffalo, N.Y./TR 3-9661
KANN-ELLERT ELECTRONICS, INC. Baltimore, Md./TU 9-4242
MILGRAY ELECTRONICS New York, N.Y./BE 2-4400
RADIO & ELECTRONIC PTS. CORP. Cleveland, O./UT 1-6060
SCHWEBER ELECTRONICS Long Island, N.Y./PI 6-6520 Silver Spring, Md./JU 5-7023

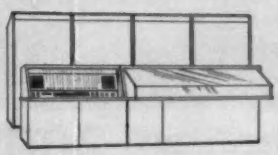
MIDWESTERN

E.C.I. SEMICONDUCTORS, INC. Kansas City, Mo./WE 1-0829
ELECTRONIC COMPONENTS FOR INDUSTRY CO. St. Louis, Mo./WO 2-9916
HALLMARK INSTRUMENTS CORP. Dallas, Texas/RI 7-8933
INTER-STATE RADIO & SUPPLY CO. Denver 4, Colo./TA 5-8257
LENERT CO. Houston, Texas/CA 4-2663
MIDLAND SPECIALTY CO. El Paso, Texas/KE 3-9555 Phoenix, Ariz./AL 8-8254 Albuquerque, N.M./CH 7-0236
RADIO DISTRIB. CO. Indianapolis, Ind./ME 7-5571
SEMICONDUCTOR SPECIALISTS, INC. Chicago, Ill./NA 2-8860
S. STERLING CO. Detroit, Mich./BR 3-2900
UNITED RADIO, INC. Cincinnati, O./MA 1-6530

WESTERN

ALMAC ELECTRONICS CORP. Seattle, Wash./PA 3-7310
ELMAR ELECTRONICS Oakland, Cal./TE 4-3311
HAMILTON ELECTRO SLS. Los Angeles, Cal./BR 2-9154 Palo Alto, Cal./DA 1-7541
NEWARK ELECTRONICS CO. Inglewood, Cal./OR 4-8440





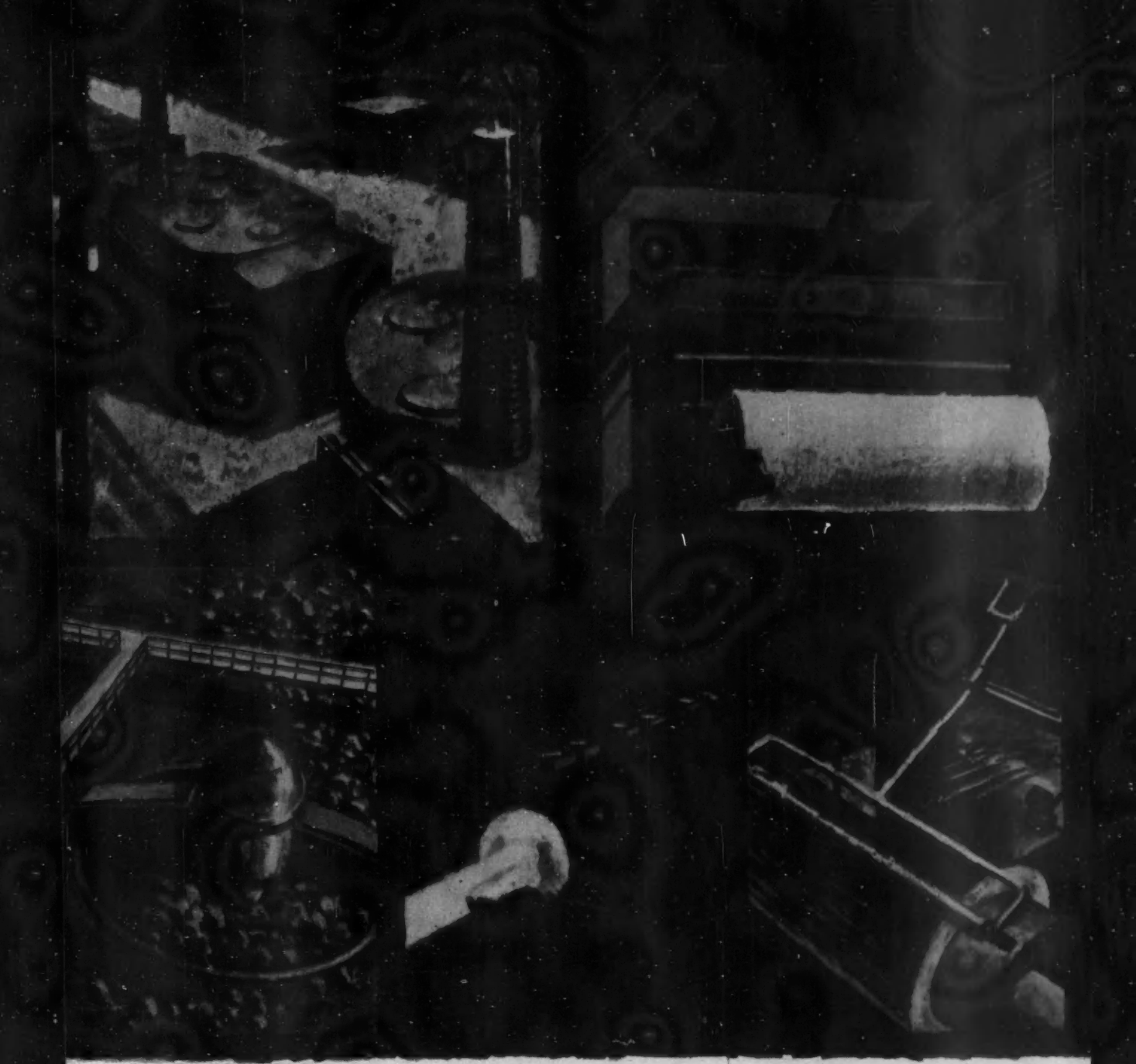
CORNERSTONE FOR YOUR AUTOMATION PROGRAM

CHEMICALS • ORE REDUCTION
PETROLEUM REFINING • PAPER • GLASS
CEMENT • ALUMINUM • UTILITIES • STEEL

PCA-2

General Electric announces the new GE 412, a second generation solid-state, stored program computer designed solely for industrial and utility applications.

The GE 412 Digital Control Computer, new "big brother" in the General Electric family of process computers, has been designed with the total systems concept and flexibility of equipment organization in mind.



The resultant versatility and capability of the GE 412 makes it custom-adaptable to many particular applications in many varied industries—data-logging and monitoring, data-logging and control, economic dispatching, director (or dispatcher) in a multi-control system.

The new GE 412 is extremely fast—capable of 25,000 additions a second. It incorporates a core memory with drum memory backup, plus more than 100 basic commands, to provide wide programming flexibility. The Automatic Program Interrupt feature and Programmable Elapsed Time Counters permit the regular survey of critical points without wasting valuable computer time required for constant checking.

General Electric offers you the two basic elements for your automation program—the new GE 412 Digital Control Computer and the application experience necessary to get it operating efficiently in your plant.

General Electric engineers can detail the available full line of input/output equipment and computer services including SYSTEM DESIGN, PROGRAMMING and AIDS, TRAINING, INSTALLATION SERVICES, and MAINTENANCE SERVICES—offered by General Electric to get your automation program in operation quickly... for lower production costs, increased profits.

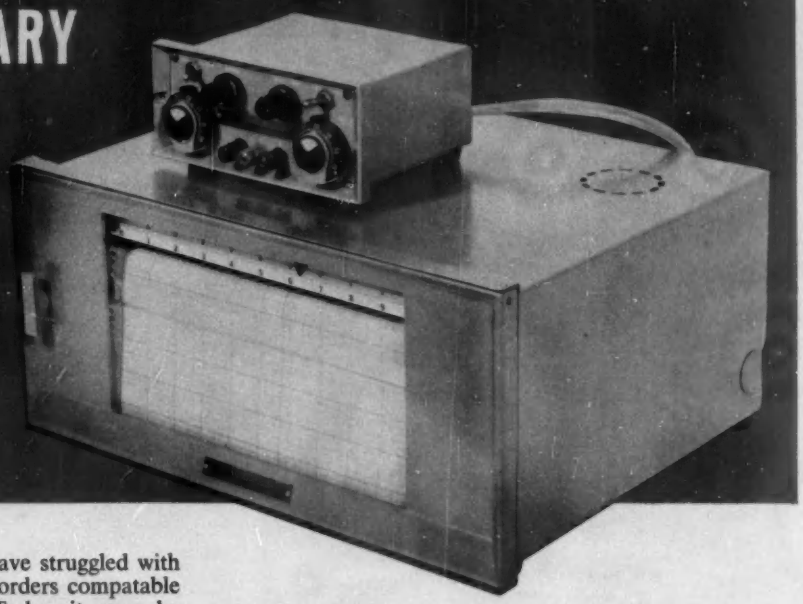
INVESTIGATE THE NEW GE 412—*contact your nearest General Electric Apparatus Sales Office or the Process Computer Section, Industry Control Department, P.O. Box 2918, Phoenix, Arizona.*
IN CANADA, *contact Canadian General Electric Apparatus Sales Department, Peterborough, Ontario.*
OUTSIDE THE U. S. AND CANADA, *contact International General Electric, 150 East 42nd Street, New York 17, New York.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

CIRCLE 47 ON READER SERVICE CARD

REVOLUTIONARY NEW CONCEPT IN RECORDING!



For years instrument users have struggled with making their potentiometer recorders compatable with changing input needs. Today it may be necessary to measure temperature, tomorrow pressure. In order to be prepared to meet these changing demands it has been necessary to stock a number of recorders, or spend hours in modifying existing input circuits.

This costly and outmoded instrumentation is no longer necessary! Westronics, Inc. now brings to the industry a totally new *UNIVERSAL RECORDER* featuring panel or table mounted *EXTERNAL PLUG-IN* input modules. Each has in itself a maximum of versatility.

- **ADJUSTABLE SPAN AND ZERO DIRECTLY CALIBRATED**
  SPAN: 1 to 110 MV Fullscale
  ZERO: ± 50 MV
- **INPUT DIVIDER, 10 STEPS**
  Voltage input to 100 volts
- **THERMOCOUPLE REFERENCE JUNCTION**
  Electronically compensated for 4 commonly used T/C types
- **RESISTANCE BULB BRIDGE**
  May be used with a variety of bulbs DC excited bridge
- **STRAIN GAGE BRIDGE**
  Tare and span adjustment
- **PLUS 20 OTHER FUNCTIONS**

MODERN DESIGN

Everything about the new Westronics Universal Recorder is modern. Nothing old fashioned about this one! Note these features:

- **COMPACT DESIGN (Only 8⅝" high)**
- **ZENER DIODE STANDARDIZATION**
- **PULL OUT CHASSIS**
- **PLUG-IN AMPLIFIERS**
- **BALL POINT PENS (That Really Work!)**
- **QUICK CHANGE CHART SPEED SELECTOR (No gears to change)**

QUALITY

The new Westronics Universal Recorder features a servo system that uses ball bearings throughout. The pen carriage utilizes ball bearing motion on a precision ground track. No troublesome sheet metal parts sliding on rods on this one. Smooth ball bearing floating action is what makes dependable Ball Point inking practical.

VERSATILITY

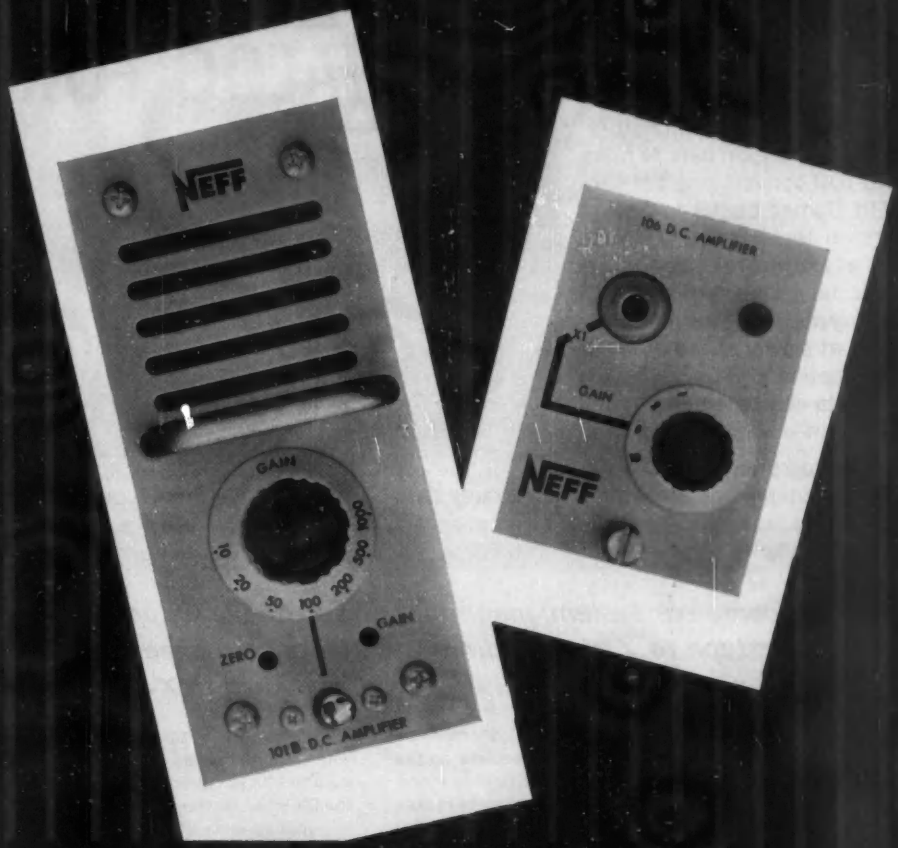
The new Westronics Universal Recorder is second to none in versatility. Available in 5" and 11" strip chart sizes, single pen, 2 pen and multipoints.

ALL THESE FEATURES AND A COMPETITIVE PRICE TOO!

CALL ON ONE OF WESTRONICS 23 SALES-SERVICE REPRESENTATIVES TO HELP YOU SPECIFY A WESTRONICS UNIVERSAL RECORDER TODAY.

wi **westronics, inc.**

TWX FT 8248 U • 3605 McCART STREET • FORT WORTH, TEXAS



NEFF INSTRUMENT CORPORATION, WITH MANY PROVEN CONTRIBUTIONS TO INSTRUMENTATION, INVITES YOUR INSPECTION AND EVALUATION OF THESE RECENTLY INTRODUCED AMPLIFIERS. THEY HAVE BEEN DESIGNED TO SATISFY TODAY'S MORE CRITICAL APPLICATIONS. NEFF CUSTOMERS KNOW THAT EACH AMPLIFIER WILL MEET ITS PUBLISHED SPECIFICATIONS. FOR *YOUR* CRITICAL AMPLIFIER APPLICATIONS — LOOK TO NEFF.

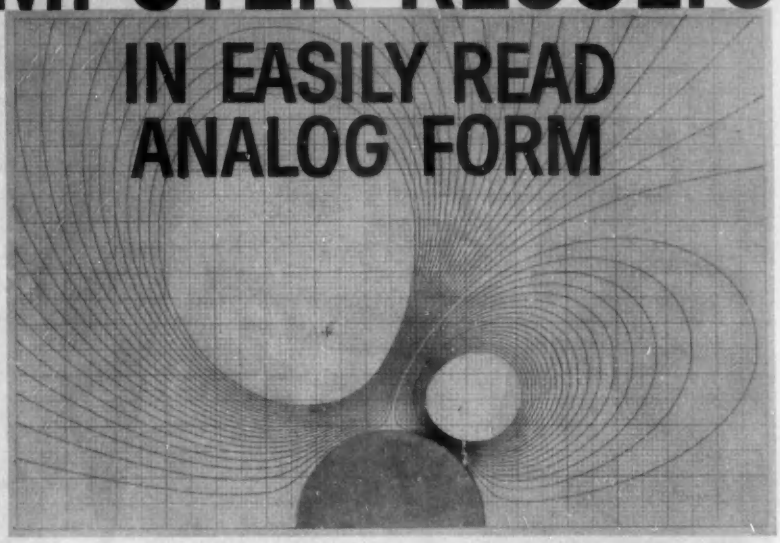
NEFF
INSTRUMENT CORPORATION
1088 East Hamilton Road Duarte, California

TYPE 101B AN EXTREMELY RELIABLE SOLID STATE DIFFERENTIAL DC AMPLIFIER COMBINING HIGH GAIN, LOW NOISE, HIGH INPUT IMPEDANCE AND LOW OUTPUT IMPEDANCE WITH INTERCHANGEABLE PLUG-IN FILTERS. THIS AMPLIFIER IS IDEAL FOR NARROW BAND REQUIREMENTS WHERE NOISE OR GROUND CURRENTS CREATE PROBLEMS.

TYPE 106 A SOLID STATE BROAD BAND, SINGLE ENDED LOW GAIN DC AMPLIFIER PARTICULARLY APPLICABLE AS A GALVANOMETER DRIVER OR LINE DRIVER. THE AMPLIFIER FEATURES HIGH OUTPUT CURRENT, LOW OUTPUT IMPEDANCE, AND OPTIMUM ISOLATION. A DUAL OUTPUT IS PROVIDED — DIRECT OR THROUGH A PLUG-IN DAMPING NETWORK WHICH ACCOMMODATES THE RESISTANCE NECESSARY TO MATCH ANY GALVANOMETER.

PLOT COMPUTER RESULTS IN EASILY READ ANALOG FORM

With Dymec Data Reduction Systems



You can make X-Y or strip-chart recordings from digital data at rates of up to 100 conversions per second with Dymec digital-to-analog conversion techniques. Data recorded at computer speeds on magnetic tape, punched cards or punched tape can be automatically plotted at slower speeds for visual examination and analysis. Additional data can be entered manually with an auxiliary keyboard.

Two moderately priced Dymec Data Reduction Systems are available. One extracts data from magnetic tape; the other is used with punched cards, punched tape or typewritten records. These systems include three types of digital-to-analog converters which are also available separately or as building blocks for custom designed data reduction systems.

DY-6575, A complete system, magnetic tape to X-Y recording

You can increase the efficiency of your high-cost computer with the DY-6575 Magnetic Tape Plotting System. Tape written at 75 inches per second on the computer is read at 3 inches per second for recording. The Dymec system makes 100 conversions/second from digital data on magnetic tape for continuous plotting on a Moseley Autograf Recorder. Accepts binary or BCD inputs, includes search mode and visual display for check-out or calibration. Overall accuracy of plotting system, ±0.2% of full scale. Complete system about $29,750.00.

DY-6242, A complete system, punched cards, punched tape or keyboard to X-Y recording

Plotting speeds of 50 points per minute with punched cards and 80 points per minute with punched tape are yours with the DY-6242 Plotting System, which also is supplied with a 10-key serial entry keyboard for recording tabular data. Overall accuracy of plotting system, ±0.2% of full scale. The Dymec system consists of a digital-to-analog converter, a tape reader and a Moseley Autograf Recorder with character printer. Complete system about $8,700.00.

Three digital-to-analog conversion building blocks

Dymec Model 2742 Digital Data Translator accepts data from IBM cards, perforated paper tape or a serial keyboard and converts for recording up to four decades of data plus a sign for each axis. The transistorized instrument provides a front-panel display for monitoring translator contents, plus controls for calibration, single cycle or automatic operation. D/A conversion accuracy, 0.1%. Price, including manual keyboard, about $4,500.00.

Dymec Model 2743 Series Digital/Analog Converters accept binary, binary-coded-decimal or decimal data for conversion to analog voltages. Up to four channels in one unit. Each can process up to 12 bits of binary, up to 4 decades BCD or decimal data. Price about $3,800.00.

Dymec Model 2744 Series Magnetic Tape Units include tape control unit and tape converters for recording binary and binary-coded-decimal data. The control unit, Model 2744A, accepts data from tape and provides an output to drive one of the converters, Model 2744B for binary data and Model 2744C for BCD data. Price, about $14,700.00, including 2744B or 2744C Converters.

Data subject to change without notice. Prices f.o.b. factory.

Call your Dymec/Hewlett-Packard representative or write direct for information on Dymec digital-to-analog conversion capabilities.

DYMEC

A division of HEWLETT-PACKARD COMPANY

DEPT. C-8, 395 PAGE MILL ROAD, PALO ALTO, CALIFORNIA • DAvenport 6-1755 • Area Code 415

TWX-117-U

7276

DOUBLE-DIFFUSED SILICON INDUSTRIAL TRANSISTORS

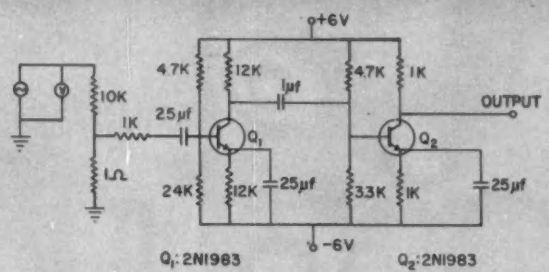
HIGH GAIN

LOW COST

FAIRCHILD 2N1983

- produces circuit voltage gains of 1,000 and up
- price is competitive with germanium and lower performance silicon
- eliminates hum and microphonics in low noise circuit design
- provides low noise circuit performance from 1KC to 150KC
- permits circuits with very low power consumption
- operates over a wide temperature range, up to 125°C.

For fast deliveries, call your Fairchild Distributor or factory field sales office. Write for complete specifications and pricing information on the total Fairchild line... Industrial Silicon Transistors and Diodes; Silicon Planar Transistors and Diodes, and Special Products.



Q_1: 2N1983 Q_2: 2N1983

CIRCUIT TEST RESULTS OF RANDOM 2N1983 SAMPLES FOR Q_1

Q_1	Noise Referred To Input in μ Volts	Voltage Gain
#1	13	1000
#2	20	1080
#3	20	1080
#4	21	1080
#5	18	1080
#6	20	1190
#7	16.2	1190
#8	18.4	1190
#9	17	1190
#10	19	1190

10 SAMPLES TESTED

MAXIMUM RATINGS at 25° C

V_{CBO} – Collector to Base Voltage 50 Volts
V_{CEO} – Collector to Emitter Voltage 25 Volts
V_{EBO} – Emitter to Base Voltage 5.0 Volts
P_D – .6 Watts in Free Air

ELECTRICAL CHARACTERISTICS (25° C unless otherwise noted)

Symbol	Characteristic	Min.	Max.	Units	Test Conditions	
V_{BE}	Non-Saturated Base Voltage		.85	Volts	I_C = 1.0 mA	V_{CE} = 5.0 V
R_{CS}	Saturation Resistance		50	ohms	I_C = 5.0 mA	I_B = 0.5 mA
h_{fe}	High Frequency Current Gain f = 20 mc	2.0			I_C = 50 mA	V_{CE} = 10 V
C_{ob}	Output Capacitance		45	pf	I_E = 0	V_{CB} = 10 V
I_{CBO}	Collector Cutoff Current		5.0	μA	I_E = 0	V_{CB} = 30 V
I_{CBO} (+150° C)	Collector Cutoff Current		200	μA	I_E = 0	V_{CB} = 30 V
V_{CER} (sust)	Collector to Emitter Sustaining Voltage (Pulsed)*	30		Volts	I_C = 100 mA	$R_{BE} \leq$ 10 Ω
V_{CEO} (sust)	Collector to Emitter Sustaining Voltage (Pulsed)*	25		Volts	I_C = 100 mA	I_B = 0
I_{EBO}	Emitter Current		100	μA	I_C = 0	V_{EB} = 2.0 V

*Rating refers to a high current point where collector-to-emitter voltage is lowest.
For more information send for Fairchild Publication APP 4

SMALL SIGNAL CHARACTERISTICS (f = 1 kc) 2N1983

Symbol	Characteristic	Min.	Max.	Units	Test Conditions	
h_{fe}	Current Gain	70 80	210 240		I_C = 1.0 mA I_C = 5.0 mA	V_{CE} = 5.0 V V_{CE} = 5.0 V
h_{ib}	Input Resistance	20 4.0	30 8.0	ohms ohms	I_C = 1.0 mA I_C = 5.0 mA	V_{CB} = 5.0 V V_{CB} = 5.0 V
h_{rb}	Voltage Feedback Ratio		7.0×10^{-4} 7.0×10^{-4}		I_C = 1.0 mA I_C = 5.0 mA	V_{CB} = 5.0 V V_{CB} = 5.0 V
h_{ob}	Output Conductance		1.0 1.5	μ mho μ mho	I_C = 1.0 mA I_C = 5.0 mA	V_{CB} = 5.0 V V_{CB} = 5.0 V
h_{ie}	Input Resistance		2000	ohms	I_C = 5.0 mA	V_{CE} = 5.0 V
h_{oe}	Output Conductance		200	μ mho	I_C = 5.0 mA	V_{CE} = 5.0 V

"See us at WESCON Booth No. 814-16"

FAIRCHILD

SEMICONDUCTOR

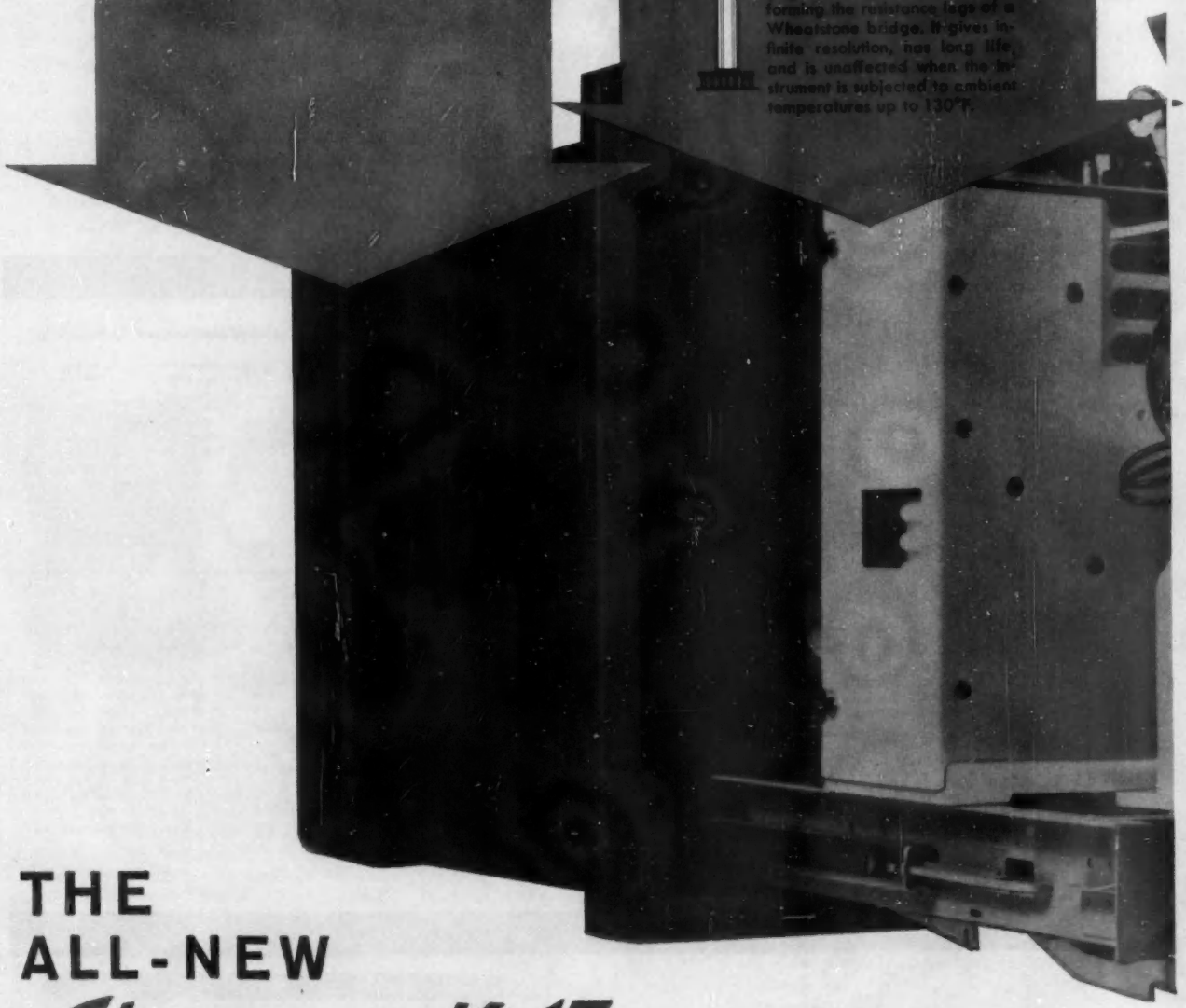
545 WHISMAN ROAD, MOUNTAIN VIEW, CALIF. • YORKSHIRE 8-8161 • TWX: MN VW CAL 853

A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

CASE MODULE
saves panel space. Circular chart and strip chart instrument doors interchangeable for simple conversion. Drawer-type chassis pulls out or removes completely for convenient access to components. All external wiring connects to terminal board at back of case for fast hookup.

DRIVE MODULE
has actuation board with quick-change range card, STRANDUCER rebalancing unit, easily removable transistor amplifier, Zener diode constant current supply, reliable two-phase induction type balancing motor. A filter network rejects loop stray signals.

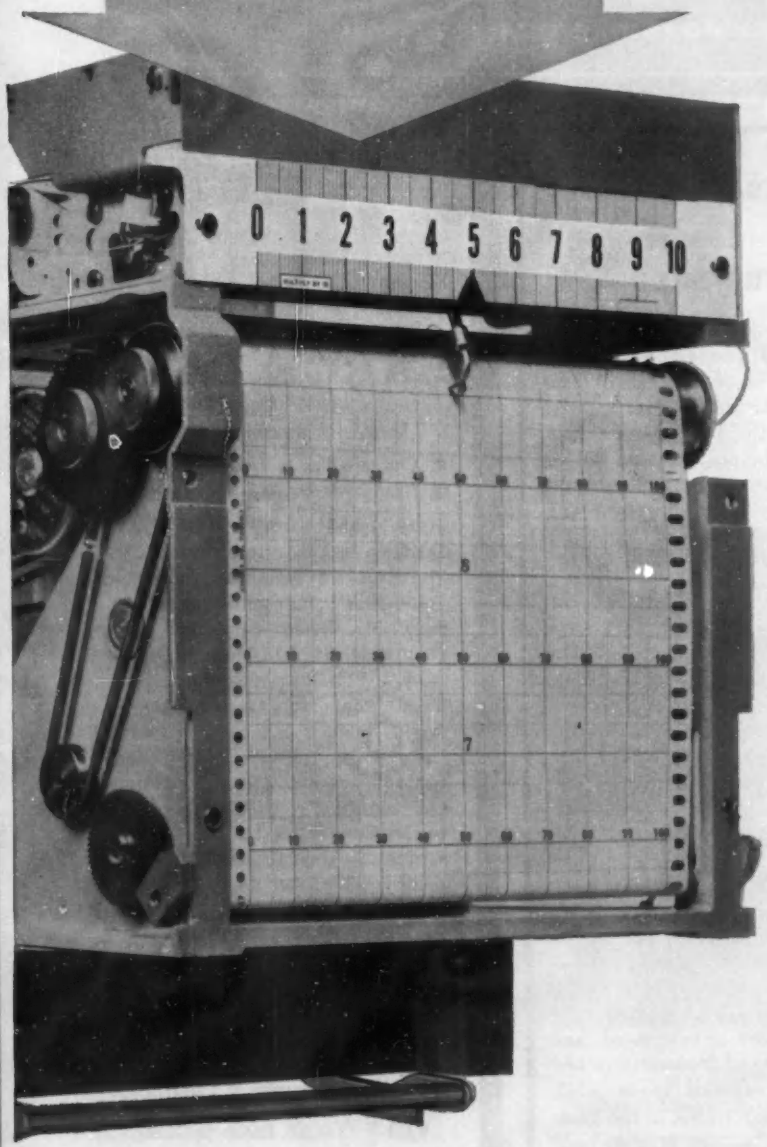
Revolutionary STRANDUCER rebalancing unit replaces slidewire. The STRANDUCER operates on the proven strain gage principle, with its four wires forming the resistance legs of a Wheatstone bridge. It gives infinite resolution, has long life, and is unaffected when the instrument is subjected to ambient temperatures up to 130°F.

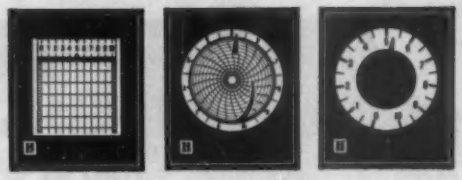


THE ALL-NEW *ElectroniK 17*

...true modular construction makes it the easiest and least expensive of all potentiometers to operate, convert and maintain

DISPLAY MODULE
is directly interchangeable with other *ElectroniK 17* front modules for conversion between strip chart, circular chart, and circular scale operation. Instruments can have up to 4 auxiliary control, and 3 zone control relays, plus the initial set point.





Here, for the first time in a small-case potentiometer, you get all the operating and maintenance advantages of modular design, plus calibrated accuracy within ±0.25%, a revolutionary new rebalancing element, the STRANDUCER, that replaces the slide-wire, and many other time-saving, cost-cutting, performance-improving features.

Three basic modules—case, display and drive—make up the *ElectroniK 17*. The case fits standard 19-inch relay racks. Attach a carrying handle, and the instrument is portable. You can easily remove front module for simple conversion from strip chart to circular chart operation. Pull the chassis out to the service position or remove it completely without tools. Vary chart speeds ½ or 2 times basic speed (1, 2, 6, 10, or 60 inches per hour) by replacing quick-change drive gears. Change range simply by changing range cards. A Zener diode constant current supply eliminates battery problems. Plug into the instrument up to 8 contact control units for widely varied control possibilities.

ElectroniK 17 instruments are available as strip or circular chart recorders, or circular scale indicators. They can have electric contact control, with all control units of convenient plug-in design.

For the eye-opening details on great new *ElectroniK 17* instruments, call your nearby Honeywell field engineer today, or write to MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. — In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control

SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan

FISCHER & PORTER

THE HIGHEST POSSIBLE QUALITY

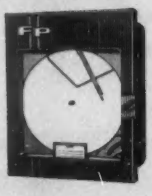
Centralized Control with Fischer & Porter Instruments

In the recent past, we have been beset by the taunts of skeptical fellows, who allege that we are naught but THE FOREMOST MAKER OF FLOWMETERS! To this allegation, we reply vehemently, "NOT SO"—and we have the fortitude to present proof of an exceedingly cogent nature to support our earnest denials. Proof, if you will, that the bonds of our PROCESS INSTRUMENT LINE extend far beyond the limits of our justly renowned flowmeters—to a multiplicity of transmitters AND a *complete* selection of PANEL instruments. Consider, if you will that we offer process instruments to measure, NOT MERELY FLOW, but temperature, pressure, liquid level, viscosity, density, pH, ORP and a great miscellany of secondary process variables. We invite your attention, in particular, to the extraordinary number of our divers devices that are available to convert the output of these multitudinous instruments to clear, accurate and repeatable signals and to transmit them instantaneously to the very heart and core of the system—that is, the CONTROL CENTER.

Again NOTE the multiplicity of these precision mechanisms diligently performing their assigned tasks at the CONTROL BOARD. Witness the amazing array of large and small case panel instruments, some with pointers, others that pen a record, with controllers secreted within (or with miniature instruments, ingeniously affixed in the rear). The number and variety of these equipments verily BEGGARS DESCRIPTION.

Need we say more? Have we convinced you? If not, may we recommend that you spend a few felicitous moments with our new PROCESS INSTRUMENTATION BOOKLET Number 310, which — be advised — is a brief, conveniently condensed presentation of the more prominent of these astounding precision devices. Here, Sirs, is indisputable evidence that we are an INSTRUMENT COMPANY—indeed, more than that—a world-wide organization, priding ourselves on the development and manufacture of transmitters and BOARD instruments to fit ANY AND EVERY KINK in the knottiest control system. May we send you a copy for your perusal? Until the post accommodates your receipt of same, may we suggest a hasty review of the following sampling . . .?

Versatile - Flexible - Adjustable



the 1100 Series

LARGE CASE

12" Chart

Recorder & Recording Controller

- *Can record up to 4 variables!*
- *Can include TWO, 3-mode controllers!*

Here, Good Sirs, is the HEAVY DUTY, GENERAL PURPOSE INSTRUMENT of the renowned F&P line! Its flexibility is unmatched. When employed as a RECORDER, it will receive up to 4—yes, FOUR!—separate and distinct signals from transmitters. As a controller it can contain two of the renowned Series 53-P, 3-mode controllers complete with gauges and regulators! And—great boon to servicers—it has a sealed inking system — guaranteeing positive records, day after day.

COMPACT & MIGHTY

The Medium-Sized 1450 Series

FIBER GLASS CASE

Indicating Receiver & Controller with 6 control mode options!

When records are not required, but GOOD READABILITY of the scale is important, the Fiber Glass Case Instrument with its 5 inch scale is pronounced by many who use it as the FINEST OF ITS KIND. It has the GREATEST

variety of control options in the industry. Amazingly, SIX different types of control are available—from on-off through three-mode! And it utilizes the same superb 53-P controllers used in ALL types of F&P instruments. This means true INTERCHANGEABILITY — and results in lowered INVENTORIES.

The exterior of this versatile instrument is formed of the new corrosion resistant FIBER GLASS material, and the door is gasketed with tenacious polyvinyl chloride. When panel space is lacking, another pointer can be added to measure an ADDITIONAL variable. Also, this device can be used as a field-mounted instrument—with control or transmission at the very point of measurement.

In-Case Alarms

When it is desired to alert the operators should an UPSET in the process occur, the clever In-Case Alarm System can be supplied. No extra black boxes—no additional exterior parts. This transistorized alarm option fits within the case and provides adjustable differentials from ½ to 15% of full scale.

The same system can also be supplied with the 1100 Series LARGE CASE Instruments.

! *NEW! NEW! NEW!*

Transistorized Pulse Receiving
2800 Series

DIGITAL DEVICES

These are the advanced devices which have ushered in whole NEW CONCEPTS in the fine art of instrumentation. FULLY TRANSISTORIZED printed circuitry, keyed plug-in boards, direct-reading measurements—are but some of the features of this new line of modern instruments which can be made to indicate, totalize, record digitally and control. They accept signals from any frequency generating device and convey data in pulse or direct reading digital form. The latest application of these futuristic instruments is with the renowned F&P CONTINUOUS IN-LINE SYSTEMS which blend two or more fluids right in a pipeline.

Truly Amazing! MINIATURE Case INDICATORS ⁂ RECORDERS ⁂ CONTROLLERS

Lilliputian magicians that can solve the TRICKIEST CONTROL PROBLEMS . . . yet fit the tightest graphic panel!

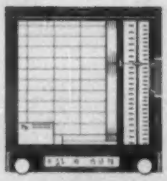
Here is a tabulation of the fabulous family of MINIATURE INSTRUMENTS which handily accomplishes every control feat of the bigger conventional units and, that notwithstanding, solve the panel designer's dilemma. These tiny devices require only 6″ x 6″ (we reiterate—only six inches by six inches) MAXIMUM PANEL AREA, yet are simply serviced by BIG-THUMBED PERSONS as all parts are readily within grasp for easy adjustment.

Consider this BROAD SELECTION of basic units . . .

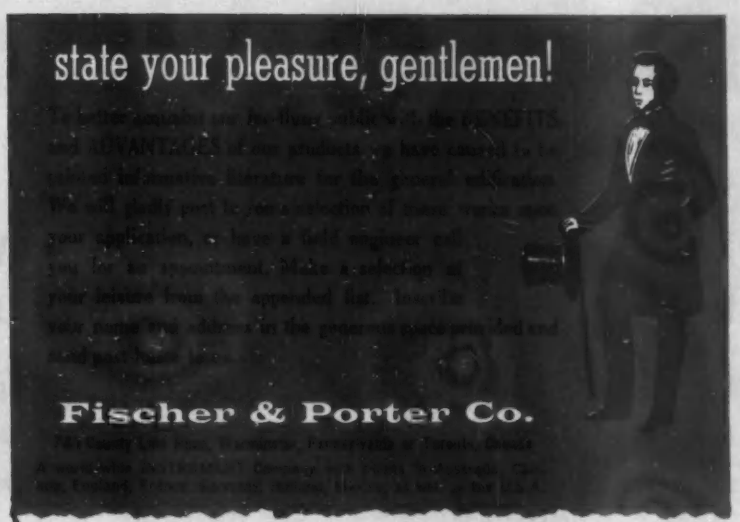
Dial-type Indicator 1200 Series
Dial is 3½″ diameter—a handy control station that operates with either a plug-in or field-mounted controller and for LOCAL or REMOTE set point adjustments.

Strip Chart Recorder 1200 Series
Records up to THREE VARIABLES on a 4″ chart with 14-hour visible record. Gasketed metal or plastic door. Can be equipped with a plug-in or field-mounted Model 53-P controller.

Drum-type Indicator 1300 Series
Indubitably clever! The drum rotates so the TRUE VALUE is always at the center of the gauge for long distance observation. Can be equipped with high or low limit ALARMS.



Indicating Integrator 1200 Series
Provides PRECISE flow rate totalization on an 8-DIGIT counter while the input variables are indicated SIMULTANEOUSLY on a 2½″ vertical scale. Surely the way to integrate!



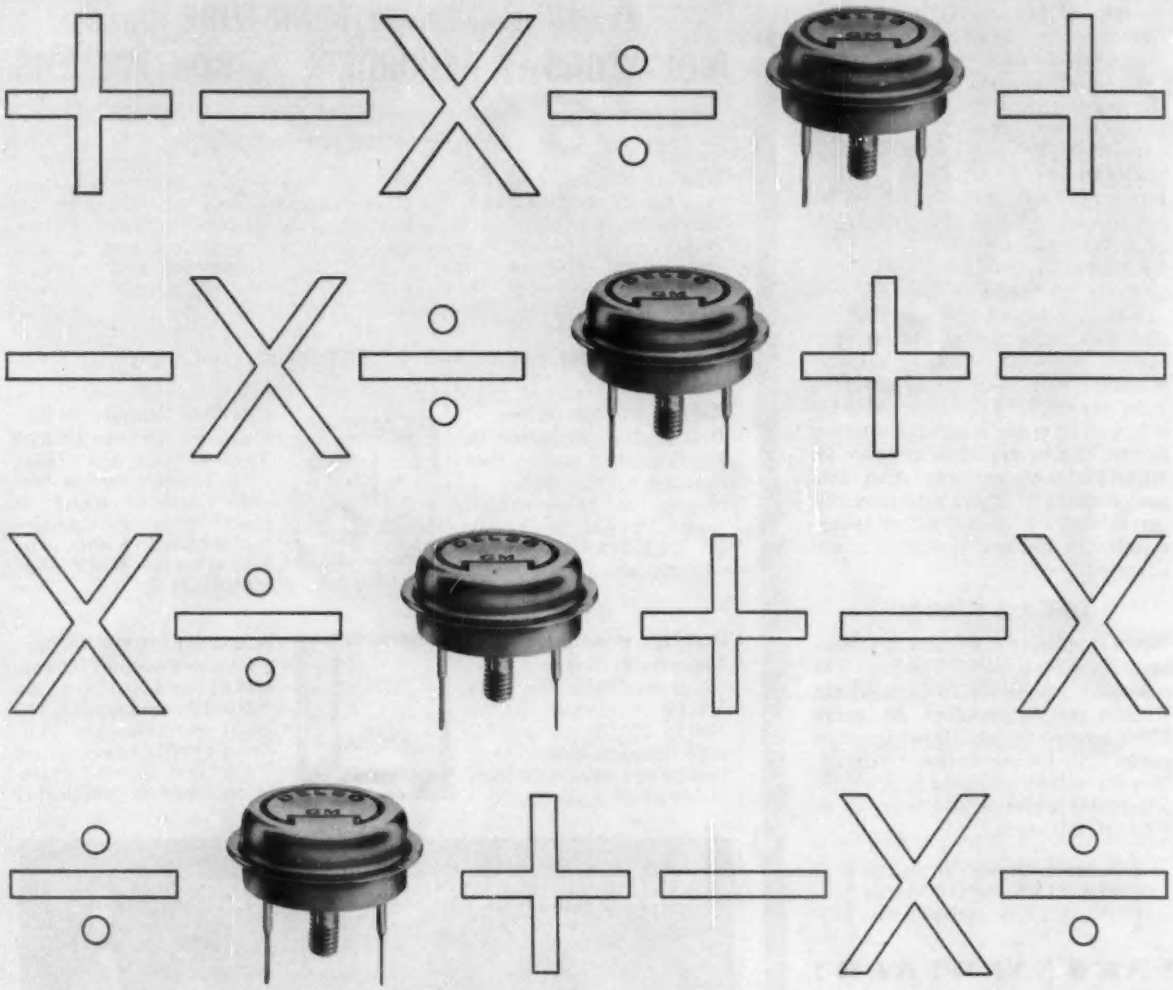
☐ Send Booklet No. 310, "Process Instrumentation"

Please post information on: ☐ LARGE Case Instruments ☐ FIBER GLASS Case Instruments
☐ DIGITAL Instruments ☐ MINIATURE Drum Indicator ☐ MINIATURE Case Dial Indicator
☐ MINIATURE Strip Chart Recorder ☐ MINIATURE Indicating Integrator

☐ Have your FIELD REPRESENTATIVE call.

NAME & POSITION_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE_____ STATE_____

CIRCLE 55 ON READER SERVICE CARD 55



DELCO POWER TRANSISTORS PROVED IN COMPUTERS by IBM, UNIVAC®, BURROUGHS, NATIONAL CASH REGISTER

Since Delco Radio produced its first power transistors over five years ago, no transistors have undergone a more intensive testing program to assure reliability—which accounts for their popular acceptance in hundreds of industrial and military uses. Before leaving our laboratories, Delco transistors must pass numerous electrical and environmental tests both before and after aging. This double testing, combined with five years of manufacturing refinements, enables us to mass produce any type of power transistors with consistent uniformity. And we can supply them to you quickly in any quantity at a low price. For complete information or technical assistance on our versatile application-proved family of transistors, just write or call our nearest sales office or distributor.

Union, New Jersey
324 Chestnut Street
MUrdock 7-3770

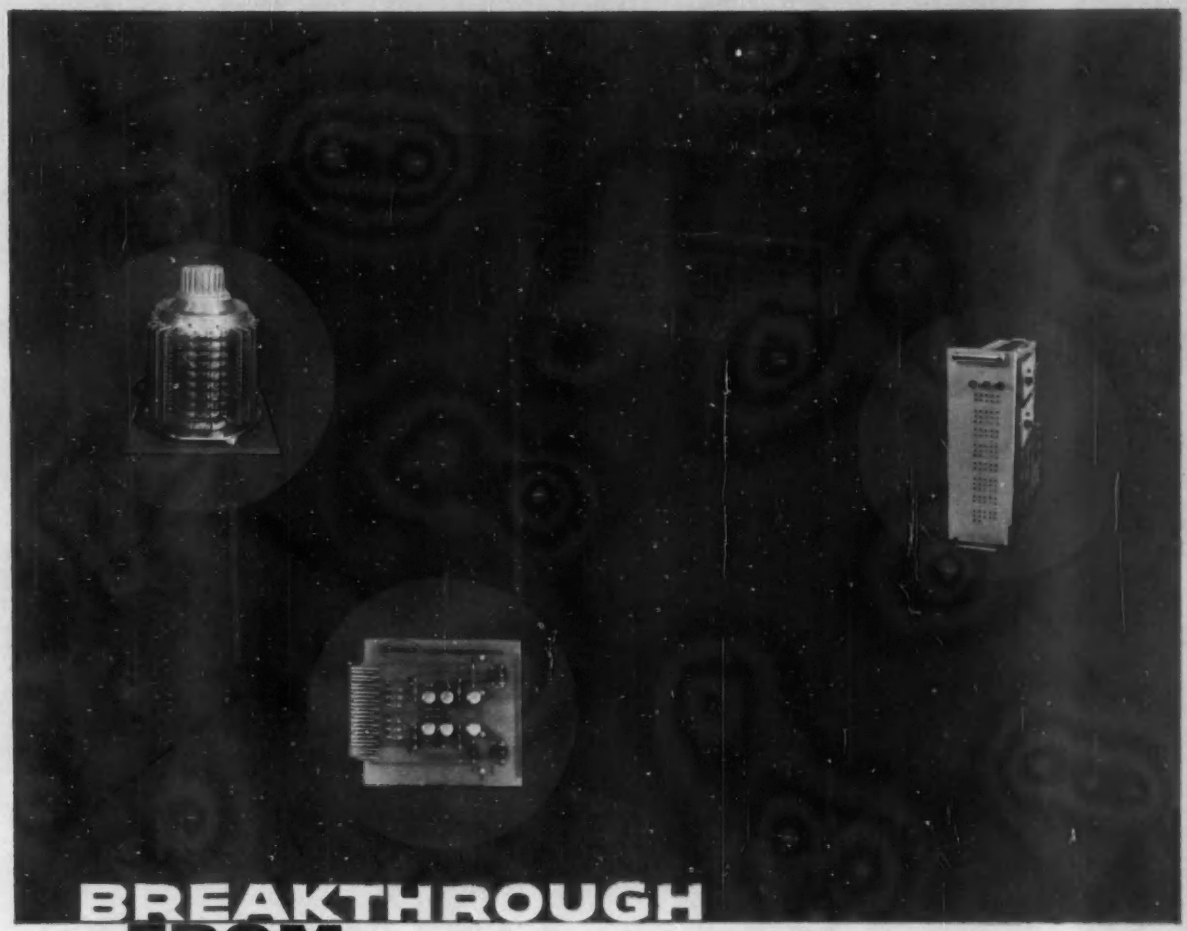
Santa Monica, California
726 Santa Monica Blvd.
UPton 0-8807

Chicago, Illinois
5750 West 51st Street
POrtsmouth 7-3500

Detroit, Michigan
57 Harper Avenue
TRinity 3-6560

DELCO RADIO
DEPENDABILITY
RELIABILITY

Division of
General Motors
Kokomo, Indiana



BREAKTHROUGH FROM BRYANT

NEW "PLUG-IN" MEMORY SYSTEMS AND CIRCUITS

Now, from Bryant . . . leading supplier of magnetic memory drums and disc files . . . complete memory systems, and a full line of modular read, write, selection, and interface circuitry . . . designed and delivered by Bryant systems engineers . . . proven in commercial, government, and military service. Memory system features include:

"Plug-In" Capability
Compatible with user logic levels
Self-contained power supplies
Standard rack mounting
Choice of recording modes

Design Flexibility
Frequencies to 1 MC
Serial and parallel operation
Selective alteration of data
Custom units for every requirement

Built-In Reliability
Complete solid state designs
Derated components, Mil-approved connectors
Glass epoxy printed boards
Overload protection

Circuit Availability
Individual circuits available include: read, write, selection, clock read, driver, inverter, flip flop, multiple gate, and power supply modules.

Whether you require a complete "black box" memory, or individual circuit modules . . . contact your local Bryant representative, or write direct.

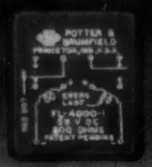
BRYANT

COMPUTER PRODUCTS

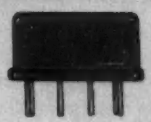
Disc File and Magnetic Drum Memories for Every Storage Application
852 Ladd Road • Walled Lake, Michigan • MArket 4-4571
A DIVISION OF EX-CELL-O CORPORATION

61-39 CP

a New and superior latching P&B relay...



LIES FLAT FOR GREATER PACKAGE DENSITY, HIGHER PERFORMANCE



This DPDT, permanent magnet, latching relay is superior on these counts: (1) shorter height for maximum compactness between stacked circuit boards; (2) greater sensitivity (80 milliwatts); (3) better vibration resistance (30 g to 2000 cps); (4) better shock resistance (100 g).

Designated the FL Series, this relay meets all applicable sections of MIL-R-5757D, MIL-R-6106C and ABMA #PD-R-187.

FL SERIES SPECIFICATIONS

Contact Arrangement: DPDT

Shock: 100 g for 11 milliseconds with no contact openings.

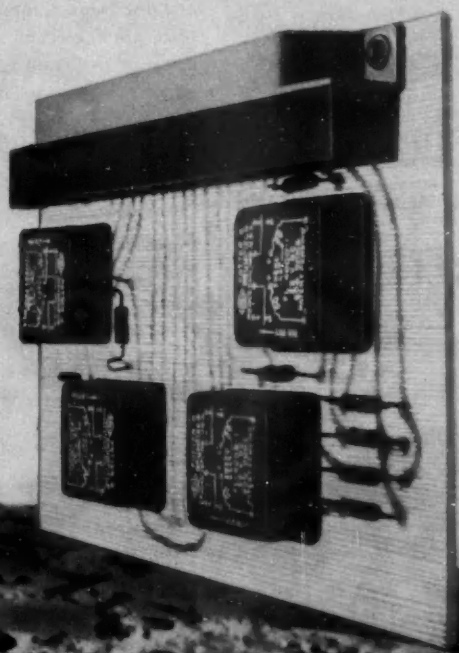
Vibration: .195" max. excursions, 10 to 55 cps. 30 g from 55 to 2000 cps. No contact openings.

Linear Acceleration: 400 g minimum with no contact openings.

Pull-In: 150 milliwatts, approx. (standard) at 25°C. coil temperature. 80 milliwatts, approx. (sensitive) at 25°C. coil temperature

Operate Time: 3 milliseconds max. at nominal voltage at 25°C. coil temperature

Dimensions: .485" high, 1.100" long, .925" wide.



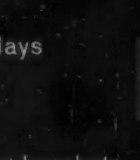
Printed circuit board using 4 FL relays was designed by the Martin Company, Orlando, as part of ground support equipment for a major missile project.

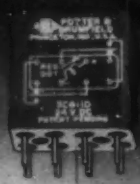
HOW P&B microminiature RELAYS can be tailored to your requirements

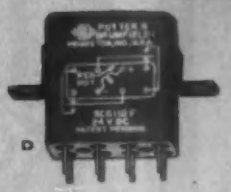
This large family of dual coil, permanent magnet relays

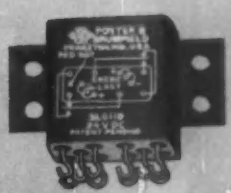
can be supplied with built-in diodes,

special terminals and mounting brackets.









A Non-latching or latching relays can be supplied in conventional crystal cases with or without shoulder brackets, studs or mounting plates. Straight pin, hook-end or 3" flexible terminals are available.

B Potting 3" terminals with epoxy resin at the relay's header keeps glass beads from cracking through mishandling during installation . . . adds only .25" max. to height of case. Your production is speeded, reliability is increased.

C A diode becomes an integral part of the relay circuit in SC or SL relays. It is incorporated in the relay case and is used to minimize arcing in special applications. Four diodes can be used as a full-wave bridge rectifier for 400 cycles.

D Terminals spaced on .200" grids are available on all P&B microminiature relays. These carry a "G" suffix (SCG and SLG) and are only slightly larger in size, measuring .890" high, .800" wide, .400" deep, max.

SC/SL SERIES SPECIFICATIONS

GENERAL:

Shock: 100g for 11 millisec.

Vibration: 30g from 55 to 2000 cps .195" max. excursions from 10 to 55 cps.

Ambient Temperature Range: −65°C. to +125°C.

Contact Arrangement: DPDT.

Contact Load: 2 amps at 30 vdc, 1 amp at 115 vac, 60 cycle.

Sensitivity: SL—230 milliwatts at 25°C.
SC—280 milliwatts at 25°C.

COIL VOLTAGES to 36 vdc.

TERMINALS:

Straight Pin: SC11D (8 pins)
SL11D (10 pins)

Hook Ends: SC11DA & SL11DA
SC11DB & SL11DB
SC11DC & SL11DC
SC11DD & SL11DD

MOUNTINGS:

Plug In: SC11D & SL11D

Shoulder Bracket: SC11DA & SL11DA

Flat Plate: SC11DB & SL11DB

Back Mount: 2 4-40 Studs: SC11DC & SL11DC

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONICS PARTS DISTRIBUTOR

POTTER & BRUMFIELD

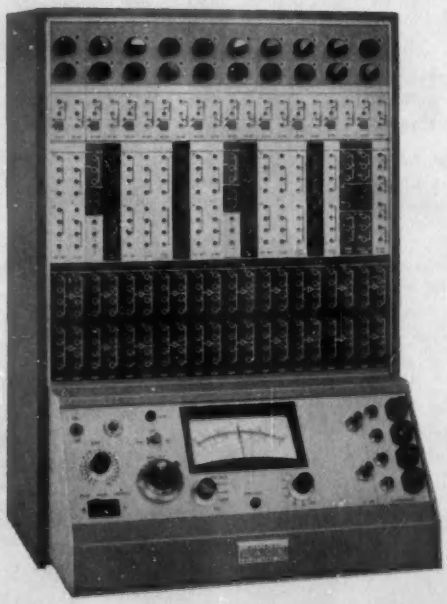
DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO

EAI *Transistorized Analog Computer*

A WIDE RANGE OF SOLUTIONS AT DESIGN ENGINEERS' FINGERTIPS...

PACE® TR-10, the first all transistorized desktop analog computer, puts proven high-speed computation right where it's needed – on the desks of busy engineers. With this easy-to-use simulator, you can quickly solve many problems without waiting for scheduled access to large-computing systems. Though compact in size, the TR-10 is a full-fledged analog computer capable of providing solutions to a wide range of design problems. Up to 20 amplifiers, plus linear and non-linear computing components are contained in one compact cabinet with no external racks. The TR-10 permits rapid evaluation of different design approaches. It demonstrates the performance of a conceptual or drawing-board design prior to construction. Thus it saves time and money normally required for multiple test models with cut-and-try engineering.



Here's How The TR-10 Saves Engineering Time

The TR-10 is especially useful in solving problems in such diverse areas as servo-system design, heat flow, chemical reaction analyses, suspension systems studies and many other problems involving dynamic conditions. Fast answers to problems posed by new design ideas immediately determine feasibility of projects. With the TR-10, engineers can explore new ideas as they occur – concentrate valuable time on the most promising area of study.

(Applications notes are available describing typical problem solutions.)

How Do You Use The TR-10?

First—Represent in equation form the physical system to be studied.

Second—Select through a simple computer diagram the computing components required to perform the calculation (programming).

Third—Interconnect these components on the computer (problem patching) and set problem parameters with adjustable controls.

Fourth—Run the problem with results presented graphically on an accessory recorder or oscilloscope.

You now have an electronic analog *model* of the physical system under study. You can manipulate design parameters quickly, running comparative solutions without becoming involved in repeated calculations. With the TR-10 you can rapidly develop truly optimum designs.

For complete details of TR-10, write for free copy of Bulletin CC821-A.

PACE TR-10 Analog Computer, including components for addition, subtraction, multiplication, division, integration and generation of powers, roots, logs, antilogs and arbitrary functions.

EAI ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

←CIRCLE 59 ON READER SERVICE CARD

CIRCLE 60 ON READER SERVICE CARD

The Market for Underwater Instrumentation

Between $4 and 5 billion will be spent to probe the ocean's depths during the next ten years. Oceanography budgets are assuming a magnitude comparable to other areas of military instrumentation for the first time.

Archiac traditions

Traditionally, oceanographers have had to improve measurement equipment and techniques on skimpy budgets. Much of the instrumentation used to probe the ocean's mysteries is archaic. In fact, the backbone of underwater instrumentation has been the simple reversing thermometer and the Nanson bottle for water sampling.

All that is changing. Probably the hardest push on underwater instrumentation stems from Navy requirements in antisubmarine warfare defenses. The atomic submarine that can cruise underwater at high speeds for long periods of time increased defense problems by an order of magnitude. Sonar, the antisubmarine weapon of World War II, doesn't have the range needed to cope with the atomic submarine. And temperature, currents, and marine life play tricks with sound waves.

August session

Other government agencies are interested too. Right now the Interagency Committee on Oceanography of the Federal Council for Science and Technology is surveying federal requirements for oceanographic instrumentation. In August, results of the survey will be discussed with industry at a special conference in Washington, D. C.

Measuring under water, in sharp contrast to measuring in air, requires completely new concepts. Sometimes the technique of handling instruments is more important than the instruments themselves. Probably the biggest differences: water, unlike air, is opaque to electromagnetic radiation, both visible and the invisible normally used for electronic data transmission; the density of water makes it difficult to get instruments to great depths; and water is corrosive—"everything wears out underwater", said one oceanographer.

Oceanography studies are getting their push right from the White House. President Kennedy himself has established an encouraging atmosphere that oceanographers have never seen before. In the coming fiscal year, which started on July 1, 1961, spending for ocean studies will jump to $97.5 million. That's a whopping increase from the $55 million spent last year. By fiscal 1963, the total expenditures will rise even more.

Navy program

Separately, the Navy has a ten-year oceanographic program that calls for total spending of around $1 billion. And these projects are in addition to its regular antisubmarine warfare expenditures that run around $235 million per year for research and development.

Much of the Navy's spending is going into these programs:

Artemis

▶Project Artemis was started by the Navy in 1958 under its Ocean Surveillance Program. Prime contractor Columbia University has built an instrumented Texas tower, called Argus Island, near Bermuda. It is crammed full of instruments for testing sound producing and listening devices.

Working with the tower is a specially converted tanker, the Mission Capistrano. An elevator arrangement lowers a room full of equipment 50 to 60 ft into the water. The ship cruises at various distances from the Argus Island and sends out sound waves that are picked up by the tower. By controlling the source of the sound, scientists can evaluate detection equipment and learn more about how sound travels through the water.

Underwater center

▶Atlantic Underwater Test and Evaluation Center is a section of the Atlantic Ocean, 20 by 100 miles, just east of Andros Island in the Bahamas. Here the ocean floor drops sharply from the island to around 15,000 ft, and remains fairly constant at this depth.

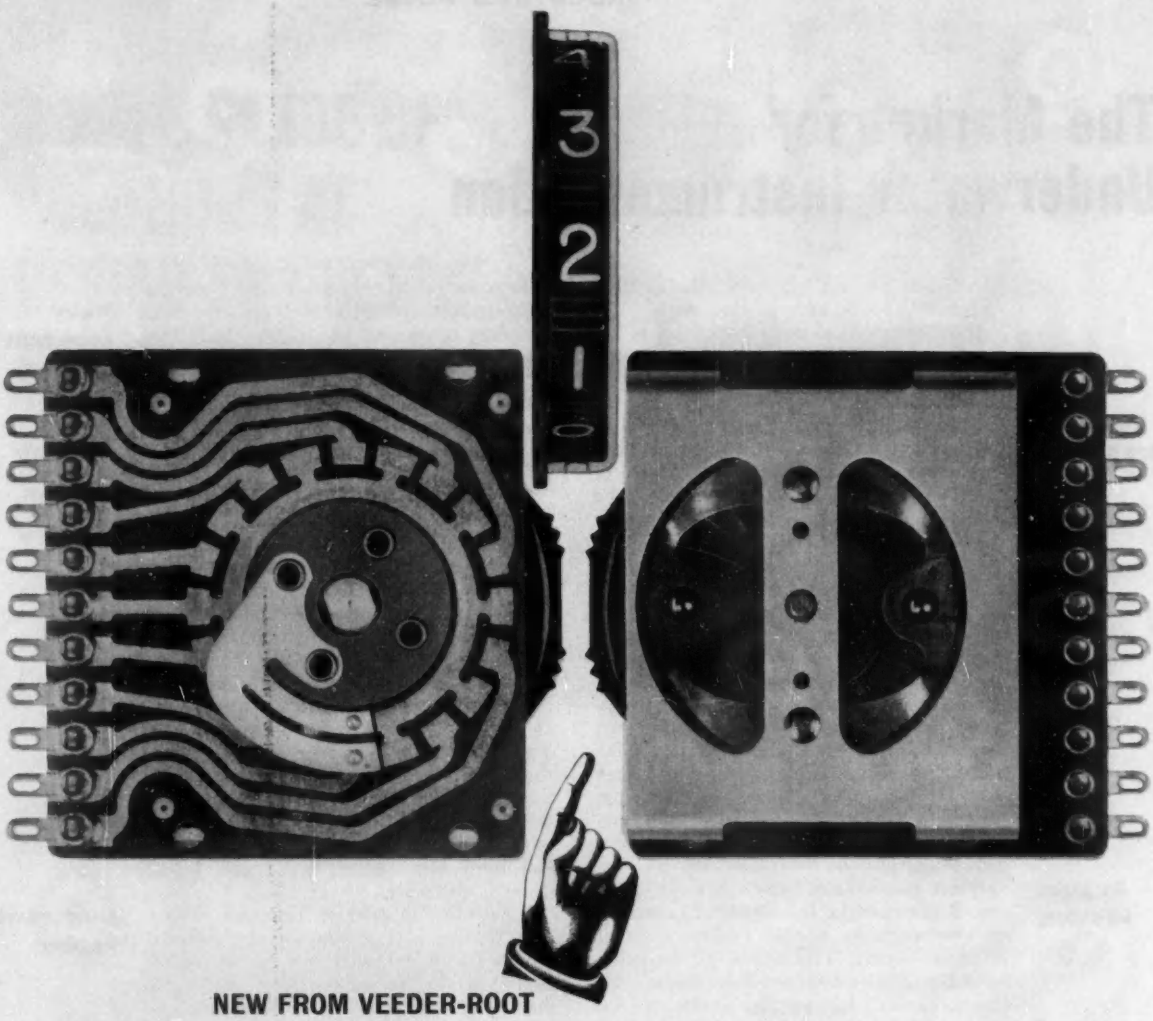
Last year, Lockheed Aircraft Corp. was given a $350,000 contract by the Navy's Bureau of Ships to study the requirements for the facility. The study will be completed in September and will include equipment needed, logistic support, communication requirements, circuitry, etc.

After the Lockheed study has been reviewed, the Navy will select an industrial manager for the project. A half-dozen companies are already working under separate contracts to develop specific equipment for the range. General Motors, for example, is working on underwater tracking equipment, The Martin Company on sound equipment. Raytheon, Philco, and others are also involved.

Target date to get the underwater test facility in use is 1963-1965. Initial cost has been put at around $100-million.

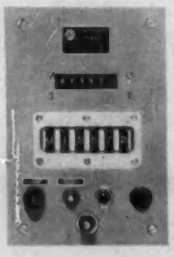
Flip and Spar

▶Flip and Spar are the names applied to two giant instrumented buoys that will go into service late this year for underwater acoustic research. At the Scripps Institu-



NEW FROM VEEDER-ROOT

Just a flick of the switch presets this Veeder-Root electrical predetermining counter. Electric rotary presetting provides compact arrangement of in-line numerals for easier legibility—even at a distance. Designers go for this counter that fits so neatly into original equipment. Other models and styles are available for existing equipment applications. All provide completely automatic recycling, automatic or push button reset. See what this versatile series can do for you. Write Electronic Controls Division, Veeder-Root Incorporated, Danvers, Mass. **count on...VEEDER-ROOT**



This new P-1801 counter for original equipment is offered in four or six decades, can be equipped for plug-in wiring. Counts 50% faster, resets 900% faster, than previous models.

Visit Booth (No. 3617-3619) at the Wescon Show San Francisco Cow Palace August 22-25

tion of Oceanography's Marine Physics Laboratory, scientists have designed a structure 355 ft long, varying in diameter from 16 ft at its bow to 20 ft at the stern.

The big steel structure, called Flip, will be towed out into the Pacific Ocean, then flooded so that it sits upright with about 50 ft of the structure above the water. Four scientists will stay in the buoy for a couple of weeks at a time collecting data while it drifts unpowered in the ocean. Cost of the buoy: about $2 million.

The Naval Ordnance Laboratory plans to build a similar acoustic laboratory to be called Spar (seagoing platform for acoustic research). It will be 345 ft long with a uniform diameter of 16 ft, and will cost under $1 million. Spar will be used in the Atlantic.

Research vessel

► An underwater research vessel that is a self-powered aluminum submarine capable of operating at 15,000-ft depths will soon be built to carry scientists to collect data on the ocean environment. It will have a 45-mile range on the ocean bottom.

Ocean net

► An ocean floor warning network that is a new approach to submarine detection is getting an initial funding from the Navy. Its developer, The Martin Company, proposes to search upward rather than downward for submarines. The plan calls for installing a network of transducers on the ocean floor every 100 miles. These would be powered by small nuclear reactors. Monitoring stations would be alerted immediately to any submarine crossing this undersea barrier.

Initial tests of the Martin theory have proven highly successful, a company spokesman says. Last December the system was demonstrated to the Navy using the Argus Island tower with sound equipment operating at a 13,700-ft depth. Tests are still in progress there, with other experiments expected to be made at different locations later this year.

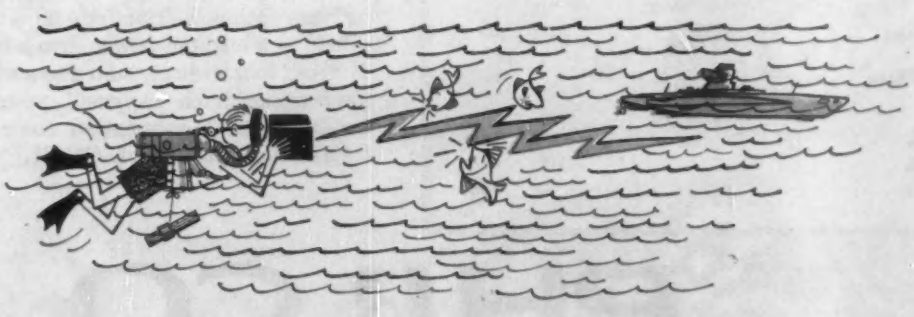
Clinker

► Project Clinker is an effort to detect submarines with infrared devices. Up to now, virtually all detection has been associated with listening to the sound made by the subs. For the past couple of years, Hughes Aircraft Company has been working on a new concept that uses an infrared technique. The theory is that a submarine moving deep in the ocean creates a temperature difference on the surface of the water for four to eight hours after it has been in an area. Hughes suggests detecting this temperature change with airborne infrared devices.

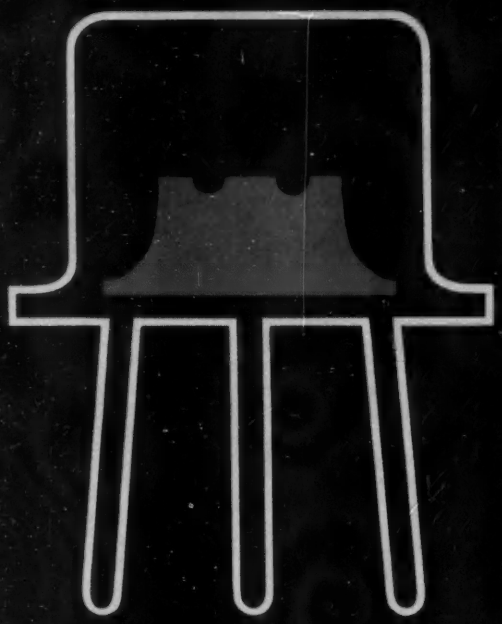
Other government projects

Although the Navy is the big spender for underwater research, other government agencies are stepping up their programs, too. Apart from the Navy's direct anti-submarine research, here is how the $97.5 million for oceanography is divided:

- Military—Army, Navy, and Air Force—increases from $22.1 million in 1961 to $32.2 million. It includes money for Arctic research and support for the new oceanographic data center established in Washington D.C. late last year to serve as a clearing house for all oceanographic data.
- Commerce Department—funds increase from $11.3 million to $24.6 million over the same period. The bulk of the money will be used by the Department's coast and geodetic survey. Included is developmental work on echo sounders, deep-sea cameras, improved automatic tide gages, current measuring equipment, and sound velocity meters.
- Department of Interior—increases from $8.7 million to $15.4 million. The largest chunk of this money will go to the Bureau of Commercial Fisheries. One program that will be pushed by BCF is to develop unmanned recording buoys for automatic data collection.
- National Science Foundation—increases from $9.1 million to $19.6 million, mainly supporting university research programs.
- Atomic Energy Commission—increases from $2.2 million to $3.6 million. The AEC program is geared to determine the effects of radiation, its dispersal, and retention in the ocean environment.
- Health, Education, and Welfare—increases from $698,000 to $1.1 million, and the Treasury Department's for the Coast Guard remains at $134,000, mainly for ice patrol work.



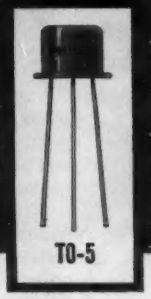
PHILCO EPITAXIAL SILICON MESA



FIRST TO COMBINE

120 V (BV_{CBO})
0.5 V(*SAT*)
150 mc. f_T

2N2087 NPN
CORE DRIVER
LINE DRIVER



ABSOLUTE MAXIMUM RATINGS

Storage Temperature .....—65 to +300°C.
BV_{CER} (R≅10Ω) .....80 volts
BV_{CBO} .....120 volts
BV_{EBO} .....5 volts
Collector Current I_C .....500 ma
Total Device Dissipation (case 25°C.) ....2 watts
Total Device Dissipation (case 100°C.) ...1 watt
Total Device Dissipation (free air 25°C.) .0.6 watt

ELECTRICAL CHARACTERISTICS (@ 25°C.)

Characteristics	Conditions	Min.	Max.	
h_{FE}	V_{CE} = 1V. I_C = 150 ma.	40	120	
V_{BE}	I_C = 150 ma. I_B = 15 ma.		1.2	volts
V_{CE}(SAT)	I_C = 150 ma. I_B = 15 ma.		0.5	volts
f_T	I_C = 50 ma. V_{CE} = 10V.	150		mc
C_{ob}	V_{CB} = 10V. I_E = 0 ma.		12	pf
I_{CBO}	V_C = 60V. T = 25°C.		2	μa
I_{CEO}	V_C = 60V. T = 150°C.		200	μa
BV_{CER}	R ≅ 10Ω I_C = 20 ma. pulsed	80		volts
t_r			85	nsec
t_s			100	nsec
t_f			55	nsec

You would expect Philco, as inventor of industry's most capable germanium logic transistor—the MADT, to design Silicon memory components with extra capability, too. And Philco has done it. The 2N2087, forerunner of a broad line of Philco epitaxial silicon mesa transistors, offers an incomparable combination of parameters that may well be the special design solution you require: maximum BV_{CBO} of 120 V., minimum h_{FE} of 40 at 1V_{CE}, maximum V_{CE} (SAT) of 0.5 V., minimum f_T of 150 mc., maximum C_{ob} of 12 pf., and maximum t_s of 100 nanoseconds.

The new Philco 2N2087 epitaxial silicon mesa delivers optimum drive for computer memory planes, serves as a medium power switch in airborne controls systems, and is ideally suited to a wide variety of other applications such as small power supplies, servo amplifiers, and automation controls. For complete information, write Dept. CE861.

Immediately available in quantities 1-999 from your Philco Industrial Semiconductor Distributor.

PHILCO®

Famous for Quality the World Over

LANSDALE DIVISION, LANSDALE, PENNSYLVANIA

TRANSISTOR CENTER U.S.A.

CIRCLE 64 ON READER SERVICE CARD

Control
ENGINEERING

AUGUST 1961

Problems Don't Necessarily Mean Failure

An experienced plant operator was heard to say: "Six of the latest electronic speed control loops were installed a while ago. They worked for a week after the vendor's engineers left and then quit one at a time. We could not afford to bother with them, so we switched back to manual rheostat control. The new gadgets have been gathering dust ever since". At a technical meeting another user wanted to know why control suppliers couldn't make rugged, reliable instruments. "The fancy new devices have to be handled like a watch, and why are there always engineers hanging over the new controls for three months after they reach the plant floor? In both cases the problems could be in the reliability and performance of the controls, but chances are as good or better that they were caused by unrealistic estimates of maintenance requirements or lack of education.

An engineer makes an economic study of a new control system, finds the returns are ample to justify it, and goes ahead and purchases and installs it. But early failures and problems bring discouragement, causing the new controls to be discarded, even though the cost of additional maintenance might not upset the economics of the situation. There is no need for this if the buyer realizes ahead of time that some of the new control equipment may need more maintenance than the old, and if he makes some attempt to get realistic estimates during the study period.

Query the vendor, find out who else has installed similar equipment, visit them, see whether they're satisfied and what their performance and maintenance experience has been. Then crank an additional cost factor based on this added knowledge into your economic justification formula and calculate potential return. If the answer still looks good you can go ahead with the satisfaction that you won't have to shudder at every little problem, that you're still making money even with the additional effort required to keep the newer controls in tune.

Closely associated with this is the problem of operating personnel acceptance. Educate them beforehand, point out what you're doing, why you're doing it, and that in the long run the process will run more efficiently and yield better product. Often this education means the difference between cooperative acceptance and outright rejection.

Do not automatically keep complex control systems out of your plant because of potential problems. See if you can't put a realistic price tag on them. They may be the best paying problems you ever invested in.

Bjorn Ledgerwood

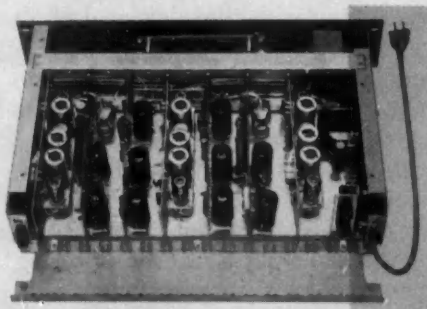
announcing...

Illustrating three of the Donner Model 3735 Dual Electronic Multipliers (6 channels) associated with one Model 3736 Multiplier Control. This equipment provides 6 independent precision multiplier/divider channels, completely self-contained in only 15¾ inches of panel height.

the new Donner model 3735 dual electronic multiplier

with **0.01%** **SINGLE QUADRANT MULTIPLICATION & SQUARING ACCURACIES**

Donner's new multiplier combines more most wanted features and high accuracies at a remarkably low cost. Check these features: **1.** 0.05% (FS) four quadrant multiplication accuracy. **2.** Completely compatible with all analog computers—no external power supplies or amplifiers required. **3.** Built-in division and square root operations. **4.** Modular construction with plug-in printed circuit cards. **5.** A 6 channel unit costs $3,800 or $633 per channel, compared to over $900 for comparable equipment.



The use of plug-in printed circuit cards in the Model 3735 Dual Multiplier assures adequate ventilation and easy access to all components. Shows 2 channel unit. Available in 2, 4, or 6 channels.

OTHER SPECIFICATIONS

INPUT Four independent voltages, X_1, Y_1, X_2, and Y_2 in the range of ± 100 volts.

OUTPUT Two independent products, $-0.01X_1Y_1$ and $-0.01X_2Y_2$, in the range of ± 100 volts at 10 ma maximum load current.

DRIFT Less than 100 mv over an 8 hour period.

NOISE Less than 100 mv, peak.

PHASE SHIFT Less than 1° at 100 cps.

ZERO ERROR With one variable = 0 and other ranging over ± 100 volts, maximum error in product is only 40 mv.

DIMENSIONS Model 3736 Multiplier Control panel 5¼ x 19 inches.

Model 3735 Dual Electronic Multiplier panel 3½ x 19 inches.

Complete technical information on the Model 3735 Dual Electronic Multiplier is ready now. Call your nearby knowledgeable Donner engineering representative, or write Dept. 21.

DONNER SCIENTIFIC COMPANY
A Subsidiary of Systron-Donner Corporation

888 GALINDO STREET • CONCORD, CALIF.
MUlberry 2-6161

32

Constant Watts Protection Keeps Power Transistors Cool

THE GIST: Fast response in controlling considerable power can be a transistor's own undoing in the case of a voltage surge or momentary short circuit. Some form of fast protection against excessive voltage, current, or power is required. Here is a circuit that senses both current and voltage, and signals for reduced input whenever too many watts are being dissipated. The authors have included all the design equations needed to fit the protective circuit to any transistor and any set of operating conditions. They illustrate the circuit's application to a dc power supply series regulator.

C. S. WALKER and A. M. ROBERTS
Low Voltage Switchgear Dept.,
General Electric Co.

Excessive current, voltage, or power dissipation will destroy a power transistor almost instantly, so any adequate protective scheme must sense all these variables and operate quickly to remove the overload. Fuses protect against overcurrent only and must be replaced when an overload does occur. It is difficult to design a circuit breaker that is fast enough but will withstand normal surges without tripping, and equally hard to be sure that an overcurrent or overvoltage relay will operate before the transistor is damaged. Current or voltage limiting circuits using transistors are simple, fast, and can be designed to be self-resetting, but they each provide only half-way protection.

The ideal circuit would multiply the power transistor current and voltage and signal whenever the product is too great. This signal would be fed back to the driving stage and used to reduce the current to a safe level for that particular voltage. The power limiting circuit described here simulates this action. It senses both voltage and current and determines whether an excessive watts situation is occurring. It protects against short circuits and turnon transients when charging currents may be excessive, and automatically returns to normal when the dangerous loading conditions are removed. The circuit is simple, can be calibrated and tested without damaging any part of the system, and is relatively independent of changes in the operating frequency.

Design approach

The hyperbolic curve in Figure 1 represents all of the combinations of voltage V and current *I* that produce constant power *K*. To protect a device from excessive power dissipation, one must choose a safe value for *K* and construct a circuit that keeps the operating point below the corresponding hyperbola. Since a transistor also has maximum current and voltage ratings, its operation must be confined to the shaded area. It will be shown later that the required transistor operating points do not follow the constant watts hyperbola, so exact duplication of this area is not required.

The approach will be that a suitable circuit should produce a specified constant output signal if any condition exists that such V times *I* equals a predetermined maximum allowable power. In constructing such a circuit, the output is held constant while the input voltage and current signals are varied to produce a curve that approximates the safe power area for the transistor. Figure 2A shows the curve that was chosen for this particular power limiting circuit. Resistors control the straight portions of

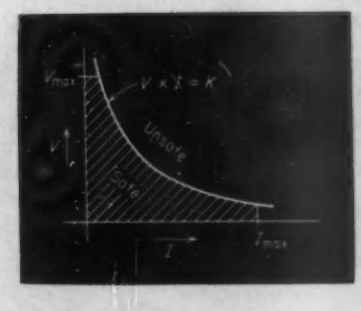


FIG. 1. Safe operating region is bounded by maximum power hyperbola and maximum voltage and current ratings.

Complete protective circuit . . .

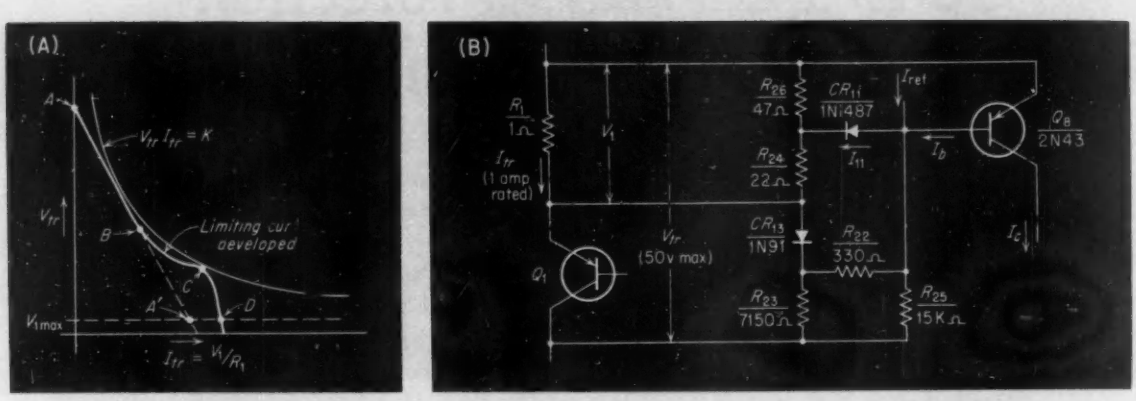


FIG. 2. Actual limiting curve (for constant feedback signal), A, approximates hyperbola. Circuit, B, keeps Q_1 dissipation within bounds; values shown are typical of one power supply application.

the curve, and nonlinear elements (diodes in this case) change the slope at points B and C.

In the actual circuit, Figure 2B, Q_1 is the power transistor to be protected, and R_1 is an emitter resistor that is required anyway if Q_1 is paralleled with other transistors. If Q_1 operates alone, R_1 must be added to the existing circuit. Note that a reference current, I_{ref}, is required, and that output current I_c is to be constant for all maximum allowable combinations of V_{tr} and I_{tr}. Under these conditions base current I_b of Q_8 is also constant.

How the circuit works

To understand how the circuit in Figure 2B operates, consider first the straight line portion of the curve, ABA′ in Figure 3A. Between points A and B, I_{tr} and V_1 are relatively small, and V_{tr} is large. As a result I_{11} is approximately zero, and the circuit reduces to Figure 3B.

Since ABA′ is a straight line, its equation must be

$$K_1 I_{tr} + K_2 V_{tr} = K_3 \qquad (1)$$

where K_1, K_2, and K_3 are constants that have to be determined. From Figure 3B,

$$I_{22} + I_{25} = I_{ref} + I_b \qquad (2)$$

Also, $\qquad BI_b \approx I_c \qquad$ and $\qquad I_b \approx \dfrac{I_c}{B}$

where B is the current gain of Q_8.

If the voltage drop across CR_{13} is the same as V_{eb}, the Q_8 emitter-base drop, then V_1 and the voltage across R_{22} are equal. Since V_{eb} is very small compared to V_{tr}, the voltage across R_{25} is approximately equal to V_{tr}. Using these relationships and Ohm's law, Equation 2 can be rewritten as

$$\frac{I_{tr} R_1}{R_{22}} + \frac{V_{tr}}{R_{25}} = I_{ref} + \frac{I_c}{B} \qquad (3)$$

Comparing Equations 1 and 3,

$$K_1 = \frac{R_1}{R_{22}}, \qquad K_2 = \frac{1}{R_{25}}, \qquad \text{and } K_3 = I_{ref} + \frac{I_c}{B}$$

At point A, $I_{tr} = 0$, and Equation 3 becomes

$$0 + \frac{V_{tr}}{R_{25}} = I_{ref} + \frac{I_c}{B}$$

At A, therefore,

$$V_{tr} = R_{25}\left(I_{ref} + \frac{I_c}{B}\right) \qquad (4)$$

At A′, $V_{tr} = V_{1\,max}$, and Equation 3 becomes

$$\frac{I_{tr} R_1}{R_{22}} + \frac{V_{1\,max}}{R_{25}} = I_{ref} + \frac{I_c}{B}$$

Rearranging terms gives

$$I_{tr} = \left(\frac{R_{22}}{R_1}\right)\left(I_{ref} + \frac{I_c}{B} - \frac{V_{1\,max}}{R_{25}}\right) \qquad (5)$$

If desired, the slope of ABA′ can also be found from Equation 3.

To show why the safe power curve bends at point B, the functions of CR_{13} and R_{23} must be considered. From Figure 3B,

$$I_{13} + I_{22} = I_{23}$$

I_{22} and I_{23} are very nearly proportional to I_{tr} and V_{tr}, respectively, so as the operating point moves down toward point B, I_{22} is increasing and I_{23} is decreasing. At some point they become equal, and current ceases to flow through CR_{13}. The circuit is then reduced to Figure 4B, and

$$I_{ref} + I_b = I_{22} + I_{25} = \text{constant}$$

The voltage across R_{25} and $R_{22} + R_{23}$ must also remain constant, and hence

$$V_{tr} = (I_{ref} + I_b)\left[\frac{R_{25}(R_{22} + R_{23})}{R_{25} + R_{22} + R_{23}}\right] = \text{constant} \qquad (6)$$

. . . and its three operating modes.

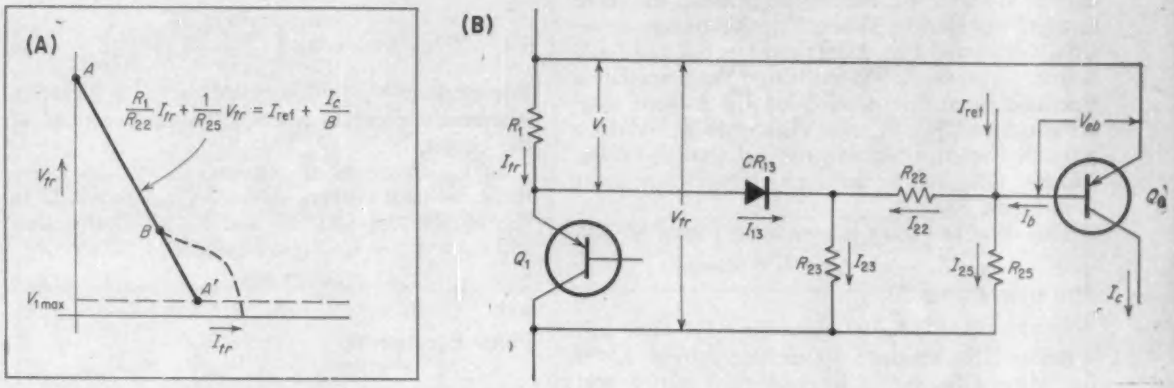


FIG. 3. Between A and B, CR_{13} conducts but CR_{11} does not, and the circuit looks like this.

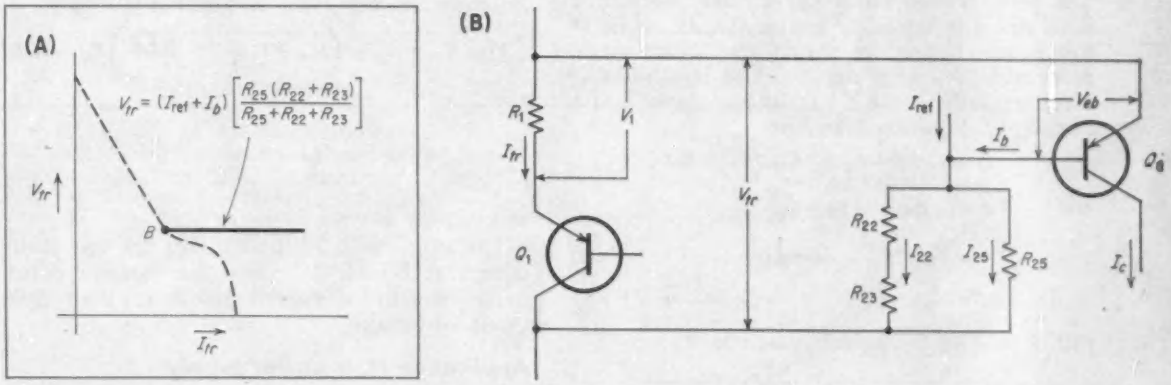


FIG. 4. At point B, $I_{22} = I_{23}$, CR_{13} ceases to conduct, and the constant I_c line bends up.

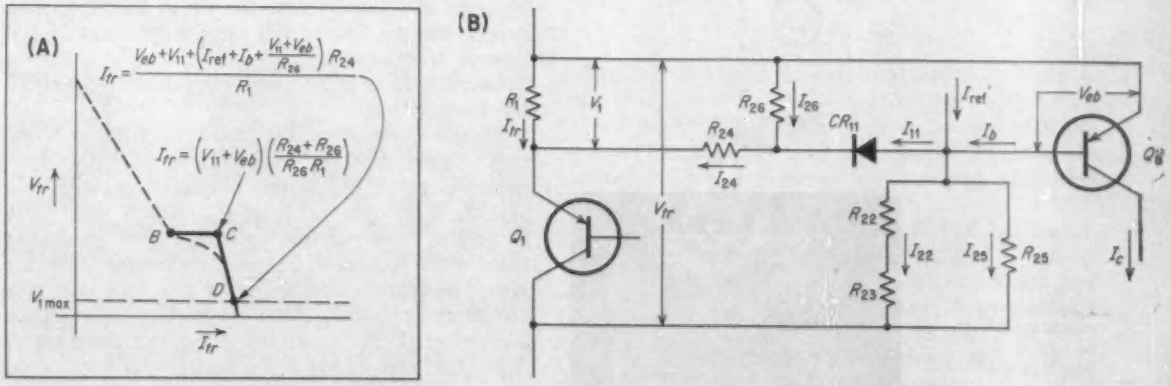


FIG. 5. Point C is where CR_{11} begins carrying most of $I_{ref} + I_b$, and the curve heads down again.

If it weren't for CR_{11} in Figure 2B, the characteristic curve for constant I_c would continue to the right as in Figure 4A, but this diode causes the curve to bend downward. When V_{11}, the voltage across CR_{11} (determined by divider resistors R_{26} and R_{24}), is low, I_{11} is small. When this voltage reaches a threshold value that depends on the forward characteristics of CR_{11}, I_{11} rises exponentially. With a properly chosen diode and the right values of R_{24} and R_{26}, CR_{11} can be made to take over near point C in Figure 5A.

The effective circuit is now as in Figure 5B and

$$I_{11} + I_{22} + I_{25} = I_{ref} + I_b = \text{constant}$$

Also from Figure 5B,

$$V_1 = I_{26} R_{26} + I_{24} R_{24} = V_{26} + V_{24} \qquad (7)$$

Before CR_{11} conducts appreciable current, $I_{24} = I_{26}$. After CR_{11} begins to conduct, it carries most of the constant current $I_{ref} + I_b$, and the voltage drop across it, V_{11}, changes very little. From Figure 5B,

$$V_{26} = V_{eb} + V_{11} \approx \text{constant}$$

The point beyond which V_{26} remains nearly fixed is C, and it is helpful to assume that $I_{24} = I_{26}$ at this point. This is not strictly true, for it would mean that CR_{11} went from blocking to conducting instantaneously, but it is a useful approximation for locating C. Equation 7 becomes

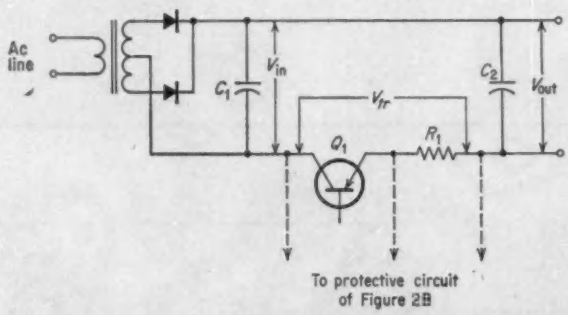
$$V_1 = I_{24} R_{26} + I_{24} R_{24} = I_{24} (R_{26} + R_{24})$$

and

$$V_{26} = I_{26} R_{26} = I_{24} R_{26} = \frac{R_{26} V_1}{R_{26} + R_{24}}$$

$$= V_{11} + V_{eb} = \text{constant} \qquad (8)$$

FIG. 6. Series regulator application and take-off points.



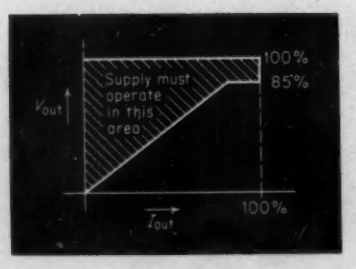


FIG. 7. Required output characteristics of typical power supply.

Thus

$$V_1 = (V_{11} + V_{eb}) \left(\frac{R_{24} + R_{26}}{R_{26}} \right) = I_{tr} R_1$$

and

$$I_{tr} = (V_{11} + V_{eb}) \left(\frac{R_{24} + R_{26}}{R_{26}} \right) \left(\frac{1}{R_1} \right) \qquad (9)$$

The values of V_{tr} in Equation 6 and I_{tr} in Equation 9 represent point C where CR_{11} takes control of the circuit.

As V_{tr} continues to decrease, I_{26} remains essentially constant. When $V_{tr} = V_{1\ max}$ (point D in Figures 2A and 5A), I_{22} and I_{25} are nearly zero, and $I_{11} \approx I_{ref} + I_b$. From Figure 5B,

$$V_1 = V_{eb} + V_{11} + V_{24} \qquad (10)$$

and

$$V_{24} = I_{24} R_{24} = (I_{ref} + I_b + I_{26}) R_{24} \qquad (11)$$

From Equation 8,

$$I_{26} = \frac{V_{11} + V_{eb}}{R_{26}}$$

Substituting this value into Equation 11 gives

$$V_{24} = \left(I_{ref} + I_b + \frac{V_{11} + V_{eb}}{R_{26}} \right) R_{24}$$

Inserting this expression in Equation 10 yields

$$V_1 = V_{eb} + V_{11} + \left(I_{ref} + I_b + \frac{V_{11} + V_{eb}}{R_{26}} \right) R_{24} = I_{tr} R_1$$

and

$$I_{tr} = \frac{V_{eb} + V_{11} + \left(I_{ref} + I_b + \frac{V_{11} + V_{eb}}{R_{26}} \right) R_{24}}{R_1} \qquad (12)$$

at point D.

The actual curve, Figure 2A, does not have sharp corners at B and C because the diodes conduct small amounts of current before reaching their threshold voltage.

Application to a power supply

In the basic dc power supply series regulating circuit, Figure 6, Q_1 varies voltage drop V_{tr} so as to set V_{out} at the desired value and keep it practically constant. $V_{tr} = V_{in} - V_{out}$ at all times. The protective circuit was designed for a particular supply with the characteristics shown in Figure 7. The supply had to deliver full rated current at 85-100 percent maximum output voltage, and V_{out} had to be variable to near zero with proportionally decreasing load currents.

Figure 8A includes V_{in} curves for high and low line voltage. For any load current (I_{tr}) the maximum value of V_{tr} is the difference between V_{in} and the minimum value of V_{out} which the supply is rated to deliver at that current. Figure 8B defines these worst normal conditions, maximum allowable power dissipation, and the curve that the protective circuit must follow. After these three curves have been plotted, the equations giving the positions of line ABA′ and points B, C, and D can be used to determine component values.

Once the shape of the curve is fixed, the whole

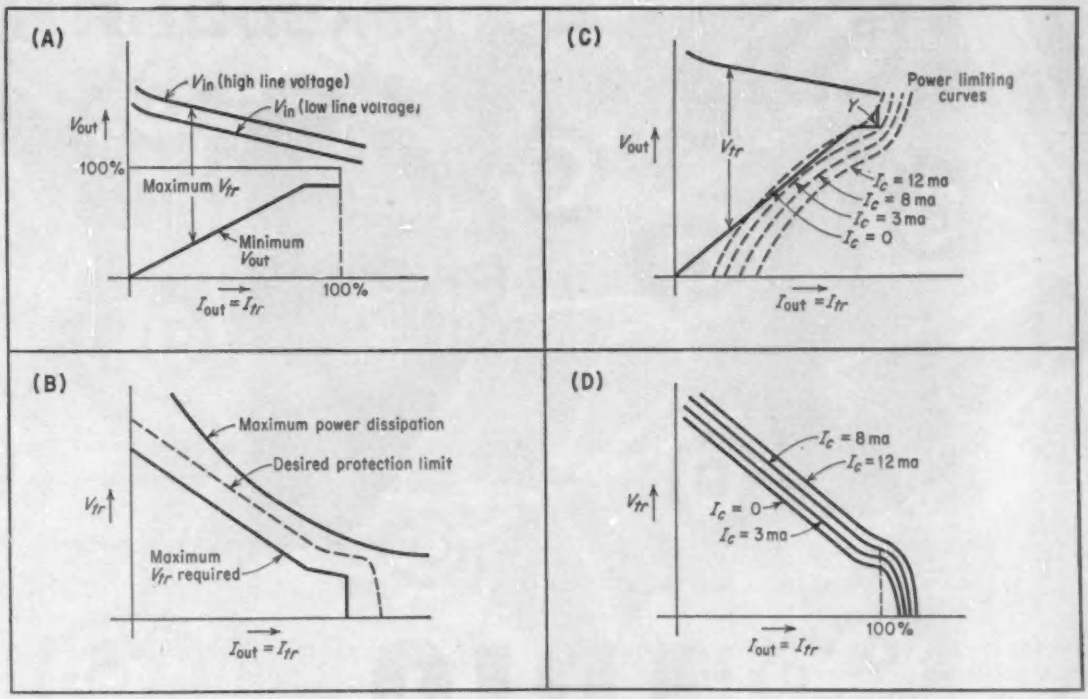


FIG. 8. Transistor has to handle difference between V_{in} and the minimum required value of V_{out} (A), and the limiting curve (B) must lie between the normal operating region and the maximum power hyperbola. Point Y (C) is the worst normal condition, and the limiting curve is shifted (D) to just clear it.

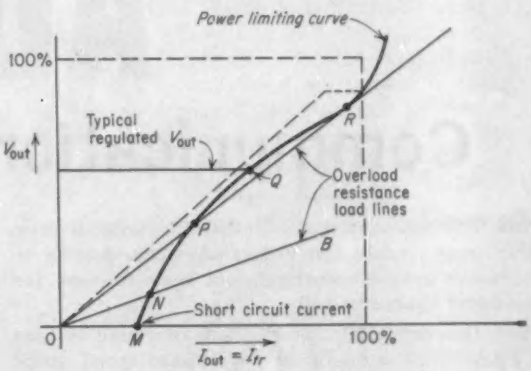


FIG 9. Load line and limiting curve intersections spot overload operating points.

curve can be shifted, Figure 8D, by varying I_{ref} to change I_c. (For given values of V_{tr} and I_{tr}, a decrease in I_{ref} produces an increase in I_c.) The point to which I_c is fed back determines the value of I_c required to return the supply to a safe operating condition. Point Y in Figure 8C represents the worst possible situation for Q_1 in normal operation and is set by the supply output ratings—V_{out} = 85 percent rated, and I_{out} = full rated. Once the protective circuit is installed, I_{ref} is adjusted until the circuit just begins to limit at this point.

With the circuit operating, the maximum current for any particular V_{out} is determined by the intersection, point Q in Figure 9, of the regulated output line with the power limiting curve. Line OB corresponds to a load resistance value that is too low; the supply is overloaded and operates at point N, the intersection of the load line with the power limiting curve. If the supply is short circuited, I_{out} will be held to approximately the value shown by intersection M.

It is also possible to have a value of load resistance represented by load line OPR, and if the resistance is further reduced, the output voltage and current may suddenly jump from R to P. This causes no difficulty in that the supply is already operating outside its normal range at point R, yet both points are within the maximum dissipation hyperbola. When overload is removed, output returns to regulated value without manual resetting.

ADIS

Communications breakthrough

New Teletype Automatic Data Interchange System (ADIS) now enables the Federal Aviation Agency to interchange aviation weather data coast-to-coast ten times faster than ever before.

With this new electronic message switching system, the FAA effects a major advance in the speed, scope and flexibility of its weather communication service—which supports all civil and extensive military aviation in the United States.

Nucleus of the system is a series of five Interchange Centers, located in Kansas City, Cleveland, Atlanta, Fort Worth and San Francisco. Each of these acts as a clearing house for a number of area circuits, or outlying "loops," collecting data from observation points on these loops and providing the area circuits with data from other parts of the country.

Teletype electronic communications equipment at the Interchange Centers carries out an automatic program of sequentially calling data-originating stations, classifying messages by priority, selecting only those weather items wanted at regional stations, and delivering them to the area circuits—while maintaining the ability to handle emergency traffic when required.

Ultra-fast communication between Interchange Centers is provided by Teletype punched tape equipment operating at 850 words per minute, utilizing the Data-Phone concept. Stations on outlying loops are equipped with Teletype Model 28 page printer and punched tape units. Speed-conversion equipment permits automatic interoperation between the national circuit and the local loops. Thus the new system, which serves some 2,400 locations, can report weather conditions from any part of the country in a matter of minutes.

The FAA, through the years, has followed a program of continually upgrading its facilities to meet the needs of the nation's growing air traffic. Teletype Corporation is proud of its part in providing communications equipment for this vital service.

TELETYPE®
CORPORATION • SUBSIDIARY OF *Western Electric Company* INC.
Dept. 21-H, 5555 Touhy Avenue • Skokie, Illinois

Reducing Process Disturbances With Cascade Control

THE GIST: Since 1947—when cascade control systems came into use in the processing industries—principal emphasis has been placed on the benefits of interlocking a primary process variable with a secondary variable and reducing the effect of disturbances entering in the secondary loop.

The author shows by analysis and transient response curves that still further advantage may be realized from cascade control by including significant process time constants in the secondary loop. Doing so reduces the over-all time constant, thus greatly improving the controllability of the primary variable when disturbances enter the process outside the secondary loop.

PAUL U. WEBB, Phillips Petroleum Co.

In a cascade control system, Figure 1, a primary variable C (level, for instance) is held closer to its desired value by interlocking a primary controller with a controller for a related secondary variable C′ (flow). The greater the static sensitivity and transfer lags between primary and secondary variables, the more important that cascaded systems be used.

The advantages of cascade over single loop control systems may be obtained from a comparison of the systems' corresponding transfer functions with respect to setpoint inputs and load inputs.

Setpoint disturbance inputs

In the past the response of a process control system to a setpoint change was primarily used to determine process characteristics. However, with the advent of such devices as computer systems and chromatographs whose step change outputs can be applied as inputs to conventional controllers, the effect of setpoint disturbances takes on added importance.

The conventional single loop control system is represented by Figure 2A, and the cascade control system by Figure 2B. For the conventional single control loop, the closed-loop transfer function of the process output C with respect to the setpoint r is

$$\frac{C}{r} = \left[\frac{HK_pG_pK_1G_1K_2G_2}{1 + HK_pG_pK_1G_1K_2G_2}\right]\frac{1}{H}$$

The transfer function of the cascade system is

$$\frac{C}{r} = \left[\frac{HK_pG_pK_2G_2K_3G_3}{1 + HK_pG_pK_3G_3K_2G_2}\right]\frac{1}{H}$$

Since the secondary loop by itself is

$$K_2G_2 = \frac{K_aG_aK_1G_1}{1 + K_aG_aK_1G_1}$$

and K_a is assumed (as it must be) much greater

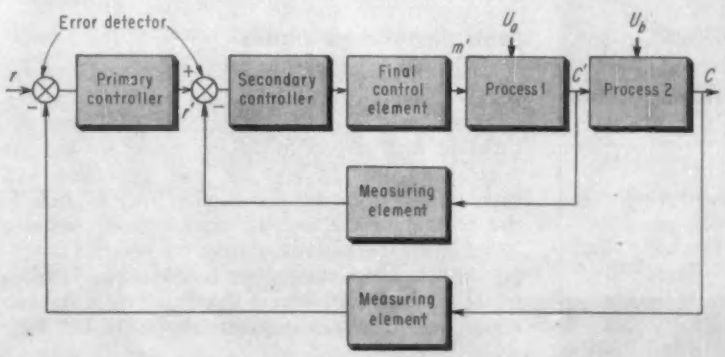


FIG. 1. Cascade control system interlocks primary and secondary variables.

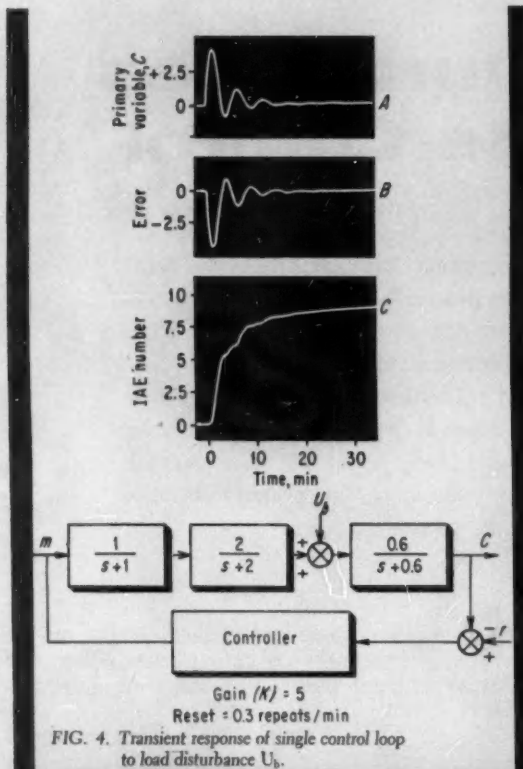


FIG. 4. Transient response of single control loop to load disturbance U_b.

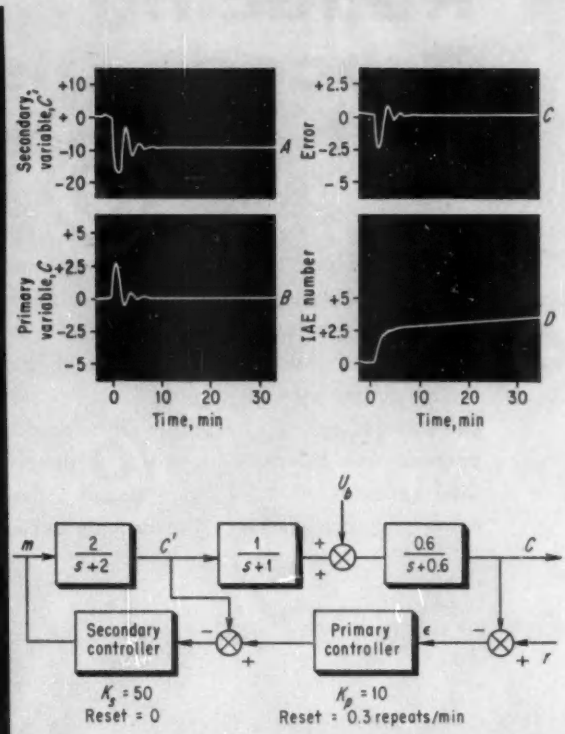
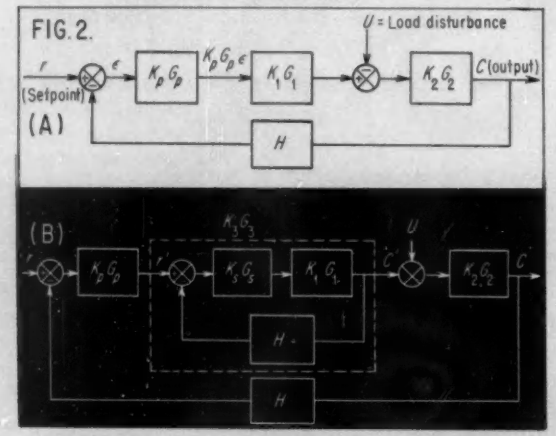
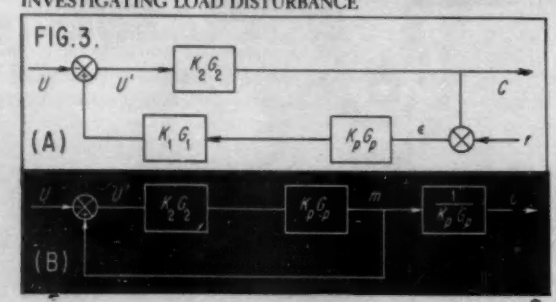


FIG. 5. ... with 0.5 min lag in secondary loop.

INVESTIGATING SETPOINT DISTURBANCE



INVESTIGATING LOAD DISTURBANCE



than unity, then the over-all closed-loop transfer function simplifies to

$$\frac{C}{r} = \left[\frac{K_p G_p K_2 G_2}{1 + K_p G_p K_2 G_2}\right]\frac{1}{H}$$

Note that in the cascade system the transfer function representing the lag of process 1 and the measuring element H has been eliminated from the main transfer function. (The term $1/H$ can be neglected in the comparison since it appears in both expressions.) Because C/r of the cascade system has a smaller number of transfer lags than C/r for the single loop, the output of the cascade system follows a setpoint change faster than the single control loop.

Load disturbance inputs

One principal objective of a process control system is to eliminate the effects of load disturbances. Comparison of the transfer function for a load disturbance with respect to process output for the two systems, Figures 2A and 2B, will show how well each system operates, particularly with relation to the portion of the over-all process time constants included in the secondary loop.

Considerable investigation has been undertaken regarding load disturbances that fall within the secondary loop of a cascade control system, but little

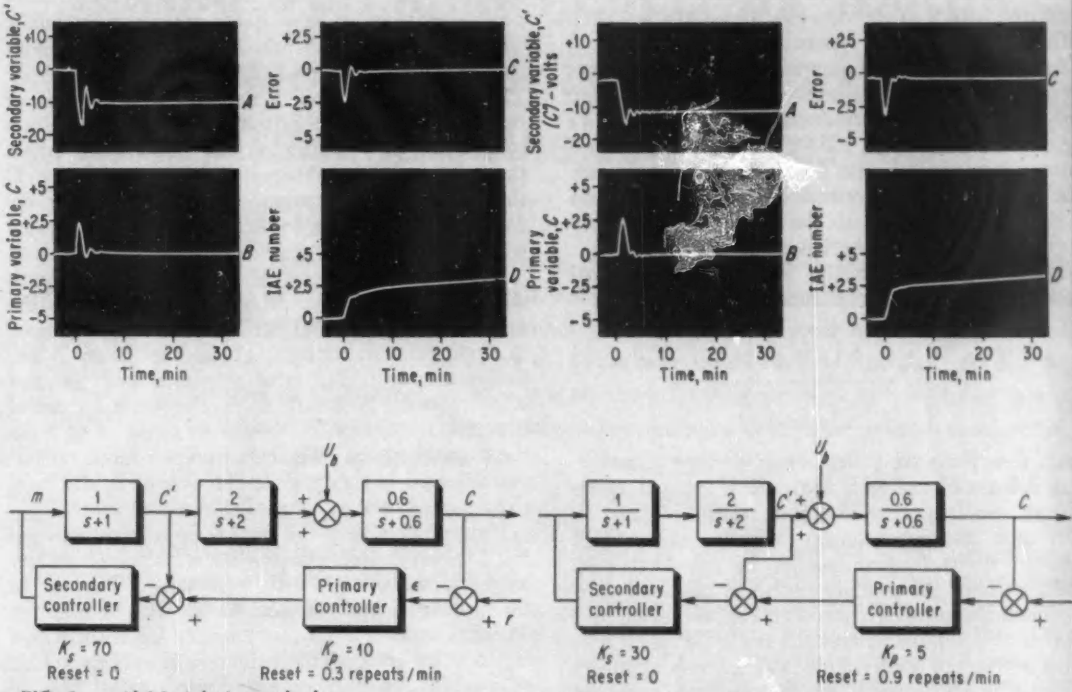


FIG. 6. ...with 1.0 min lag in secondary loop.

FIG. 7. ...with 0.5 and 1.0 min lags in secondary loop.

work has been done to show the merits of such a system when the load disturbance falls in the primary loop, not the secondary loop. This type of disturbance will be investigated here. The transfer function of interest is C/U.

For the single loop system, Figure 2A, the transfer function is

$$\frac{C}{U} = \frac{K_2G_2}{1 + HK_pG_pK_1G_1K_2G_2}$$

and for the cascade control system, Figure 2B, the transfer function is

$$\frac{C}{U} = \left[\frac{K_pG_pK_2G_2}{1 + K_pG_pK_2G_2}\right]\frac{1}{K_pG_p}$$

It is quite difficult to compare the two systems using the literal form as given by the two preceding equations, but the block diagrams derived from the equations, Figures 3A and 3B, aid in the recognition of the outstanding differences. A system that performs well has a configuration that forces the output to follow the setpoint rather than a load disturbance. Thus, ideally the performance criteria are

$$C/U = 0 \quad \text{and} \quad C/r = 1$$

where 0 means no coupling and 1 tight coupling.

Figure 3A shows that the single loop system has only one transfer lag K_2G_2 in the forward path, so that C and U are more tightly coupled than is desirable. Output C will follow a load change U too readily. In the cascade system, Figure 3B, C does not follow U so quickly because of the loose coupling due to the primary controller, and process 2 lags in the forward path.

Furthermore, the multiple lags in the feedback path of the single loop cause any change in C due to a change in U to be delayed, thus maintaining U' at a large value. This could cause an even greater disturbance at process output C. However, the cascade system has no lags in its feedback path so any change at point m is quickly fed back to reduce the disturbance. Even when a disturbance appears at point m the extended portion of the process $1/K_pG_p$ will attenuate it so C is affected even less. This attenuation, proportional to $1/K_p$, the primary controller proportional band, can be quite important in maintaining C at its setpoint value rather than letting it follow the disturbance.

Studying cascade configurations

A linear third order process was investigated using analog simulation to determine the effect on control—when a disturbance enters outside of the secondary loop—of including various portions of the process. The process has three lags, with time constants of 0.5, 1.0, and 1.67 min. In the figures

on pp. 74 and 75, these time constants are shown in their transfer function form. The process was simulated first with a single loop control system and then with a cascade control system.

In the cascade configuration, the major process lag of 1.67 min was always in the primary loop, and the disturbance introduced to test the system's regulating ability was a step change that always entered the process just before the 1.67 min lag. The secondary loop contained either the 0.5 min or the 1.0 min lags (with the other in the primary loop) or it contained both smaller lags.

The simulated controller had proportional and reset modes. Its transfer function is

$$\frac{\theta_o}{\theta_i} = \frac{K\left(s + \frac{1}{T_i}\right)}{\left(s + \frac{1}{200\ T_i}\right)}$$

Here, T_i is the reset (integral) mode time constant. The 200 associated with the pole is integral mode gain at zero frequency, and K is controller gain.

In each case approximate controller adjustments were arrived at by first tuning the secondary controller without the primary controller cascaded onto it. Then the primary controller was connected and approximate adjustments were made on it. Optimum setting of each mode was accomplished by minimizing the integral of the absolute value of the error (*IAE*) in the primary variable. Since this was a simulated process, the physical variables are given in the dimensions of the analog domain, that is, in volts. For instance, the load disturbance was 10 volts. Of the functions that were recorded, the two important ones were the values of the primary variable *C* and the *IAE*. Others are useful, however, in making a complete analysis.

Figure 4 is a record of performance of a single loop control of the process. Curve *A* is the response of the controlled (primary) variable after a step change load disturbance. Curve *C* is the *IAE*; its maximum value of 9 volts furnishes a performance index for evaluating the three other control configurations.

Figure 5 depicts the performance achieved by cascade control with the 0.5 min transfer lag in the secondary loop. The best controller setting showed that no reset action was needed in the secondary controller since a very high gain is permissible. Theoretically, this 0.5 min lag is reduced to about 0.01 min by the secondary controller's gain of 50. This high gain causes a definite improvement of performance by this system over the single loop system ($K = 5$) when a load disturbance enters the process at the designated location. Curve *D* shows that the maximum value of *IAE* was decreased from 9 volts to 3.5 volts when compared with the single loop system.

Curve *A*, the output of the secondary loop, is also the output of the primary controller since the secondary loop transfer function has been reduced to approximately unity. Thus, the primary controller output is the error amplified with integral action added. At steady state, the 9-volt output of the primary controller shown in curve *A* is from the integral mode. Thus the integral mode output permits load changes while the output is still held close to the primary controller setpoint value.

Figure 6 illustrates the further improvement when the 1.0 min process transfer lag is in the secondary loop and the 0.5 and 1.67 min transfer lags are in the primary loop. A gain of 70 with a negative feedback around a 1.0 min transfer lag reduces this lag to 0.014 min. This reduction results in a *IAE* of 3, which is a decrease over Figures 4 and 5.

Figure 7 shows a cascade control system with both the 0.5 and 1.0 min transfer lag in the secondary loop. The *IAE* curve shows that control of the primary variable deteriorated slightly over that of Figure 6 but was better than Figure 4 or 5.

The output response has a small high frequency component which is added to a larger slightly under-damped component. The higher frequency component is caused by two complex poles in the secondary loop. The slightly under-damped component is generated by the single process transfer lag and the pole and zero of the reset mode. If the secondary controller gain were reduced the higher frequency component would be reduced but a larger dc component would result. It was found that the secondary controller settings were more critical in this case than in others.

Even though the time response of the system in Figure 7 is not as good as that of Figure 6, this configuration still has an advantage which the other does not have. That is, the probability of disturbances falling inside the secondary loop is greater. These disturbances can be regulated out very quickly with little effect on the primary variable. However, the settings of the controller modes become more critical. Figure 8 shows the effect of reset action in the primary controller with various secondary controller gains for the configuration in Figure 7. Furthermore, with multiple order lags in the secondary loop some reset and rate action in the secondary controller will prove beneficial.

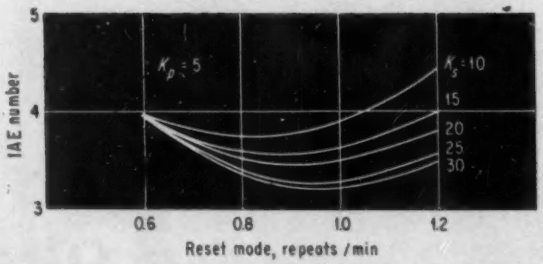


FIG. 8. For configuration in Figure 7, some reset improves control, too much deteriorates control.

Wiring Terminal Panels by Machine

—Computer assists in layout
—Wiring machine completes job

THE GIST: Machines are improving the wiring of complex terminal boards and panels in two different ways. A computing machine checks designs and makes drawings, saving designer man-hours. Then a wiring machine, working from a computer-produced deck of cards, takes over, enabling one machine operator to become as productive as 13 wiremen. Over 23,000 connections have been made in 24 machine-hours. The combination speeds up both design and production, and reduces cost in both.

RAY K. GRIM General Products Div.,
International Business Machines Corp.
DONALD P. BROUWER Gardner-Denver Co.

Use of modules simplifies both design and production of a system. Working with standard modules, a designer can assemble them into whatever structure or relationship is required. Production can be set up to produce many identical modules quickly and efficiently. Then pin-to-pin connections are wired on the back of a panel receiving the plug-ins, to match the standard modules to varying logic network requirements. Appropriately connected, the simple building blocks become a complex decision-making system.

But laying out the physical connections of a design is time-consuming, and the manual pin-to-pin wiring of a panel is far less efficient than the mechanized production of identical modules. Realizing that this potential bottleneck would choke anticipated production levels, manufacturing research looked for a more efficient method of handling both the planning and the wiring of the connections. The result of this two-pronged approach is a computer assist program for the design phase of laying out panel wiring, and a mechanized replacement for hand wiring the pin-to-pin connections.

COMPUTERS ASSIST DESIGNERS

Logic drawings are the basic document from which input to the computer is prepared because they are a desirable format for human comprehension and communication. Every pin and signal line on the drawing is given a two-dimensional alphanumeric code identifying the connection set or net. This information is then keypunched and the resulting deck of cards fed to the computer. Flow of information is from design engineer to the computer and back to the designer.

Prior to loading the logic deck into the computer, the computer program is given extensive information concerning each of the modules being wired. The complete module description is entered using punched cards and is stored on magnetic tape. The module circuit is completely described. Pins are identified—whether input or output, whether logic or nonlogic function. Types and amounts of acceptable loading, types of tests applicable to each pin, types of interconnections forbidden, and so forth are described. Armed with this exhaustive description of each module, the computer program examines module-to-module hookup as implied by the logic drawing, and tests logic and hookup against criteria established by design engineering.

Design checking

Criteria in the program examine both logic and wiring for suitability as a system, and diagnose the logic designer's plan. The diagnostic routines provide written comments on four major sets of conditions that might require additional attention from the design engineer: 1) input data errors, 2) deviations from acceptable usage of circuits, 3) erroneous or incomplete connections, and 4) discrepancies in assigning plug-in modules.

The diagnostic routines thus do not actually accomplish any of the design of the logic, but instead check the design effort against established criteria of system acceptability. Computers can check more efficiently than humans, so the diagnostic routines relieve the design section of a considerable and tedious workload. At the same time, when a logic subsystem design causes no adverse comment after

submission to the computer, the designer can be reasonably sure that the subsystem design will perform adequately as a system and that it is compatible with the larger system.

Design drafting

Much of the data-handling load of computer design is also absorbed by the program. Two sorts of tasks are encountered in this phase of the design effort: the first, simply creating the paperwork and records necessary to the operation; and the second, keeping such records and documents up to date as change orders and design modifications occur. Keeping design records up to date is accomplished between the computer and a tape storage unit by an updating routine. Each time a circuit, logic connection, circuit test, acceptability criterion, or other item is changed, the taped master file is updated. Thus, after a change has been made in the file, all the logic designs in the file and all the new designs subsequently submitted for diagnosis are examined in terms of the new data. This kind of paperwork can be confined to the tape file, avoiding the confusion normally encountered with the proliferation of outdated design records.

Outputs resulting in records external to the computer include printed logic diagrams, printed logic drawings for panel fabrication, bills of material, wiring lists, connection lists, component counts, and various other documents.

Punched card output of the computer program serves as input to the Gardner-Denver wire wrapping machine. Control decks for the wire wrapping machine can also be computer-produced from a deck of cards containing the desired wiring and routing specifications. Whether the computer works from logic drawing input or from a wiring deck input, preparation of the machine control deck is basically a translation operation. The input deck would list a pin location as B-12-R (row B, twelfth module connector, pin R on that connector), whereas the wire-wrapping machine sees this same pin on a Cartesian grid, located 37 increments along the X axis from zero and 46 Y increments from zero.

Computer output for wiring is punched on binary coded cards. One card contains all the information

COMPUTER PANEL WIRING

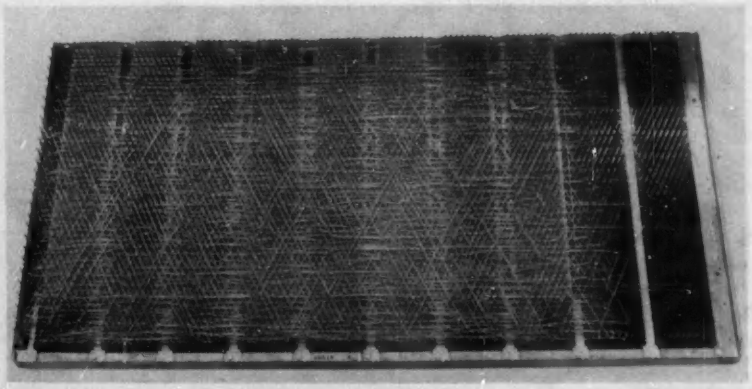
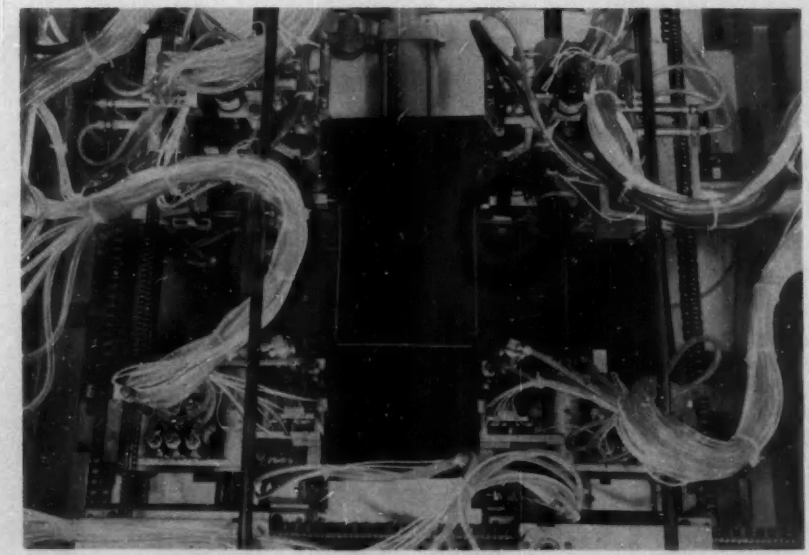


FIG. 1. Profusion of wires and closely spaced pins typify computer back panels.



WIRE-WRAPPED BY MACHINE

FIG. 2. Gardner-Denver "Wire-Wrap" (trade mark) card-controlled machine completes a wiring sequence in about 5 sec.

required to attach one piece of wire at both ends. Routing can be direct (straight-line) or indirect (using "via" points), but must avoid an accumulation of wires across the middle of the panel, excessively long lines, and line-to-line interference as much as possible.

TAPE-CONTROLLED WIRING

Confronting either the wireman or the wire wrapping machine are 4,480 pins protruding through the black phenolic resin of a panel. In manual wiring production, the wireman works from a wiring list containing "From", "Via", and "To" specifications for each wire. Selecting a prestripped length of wire (length is indicated on the wiring list) and using an air powered wire wrapping tool, he attaches one end of the wire to the "From" pin, routes the wire, and connects the other end to the "To" pin. This operation is repeated, following the list, until a completed panel results, as shown in Figure 1. Because of the close proximity of pins (0.125-in., center-to-center), the number of connections, and density of wiring, human errors occur. Troubleshooting such errors adds to the time required for an already time-consuming operation.

The mechanical counterpart of the wireman is equipped with a reel of wire, strippers, cutters, dressing fingers for routing the wire around corners, and wire wrapping heads. Wiring instructions are fed to the machine by a deck of punched cards. Movement data (cols. 6, 8, 19, 12, 14, 16) is in binary, giving the destination point on a 0.125-in. Cartesian grid. Routing data (cols. 3, 5, 7, 9, 11, 13, 15) selects the order of tool slide movement.

To route and attach a length of wire in the U-pattern shown in the middle of Figure 2, four different points must be described on the card in XY coordinates and located by the machine's controlled members. Two "Via" points locate the dressing fingers around which the wire is bent (bottom corners of the U-shape) and two points locate the wire wrapping heads that descend and wrap the wire around the "To" and "From" pins (stem ends of the U). The several controlled movements required to wire this configuration are listed in the text accompanying Figure 3.

NOMENCLATURE

Symbol	Designates
A	"A" carriage
B	"B" carriage
C	Couple
D	Dresser
F	Front
R	Rear
T	Tool for wrapping
X	Longitudinal axis
Y	Transverse axis

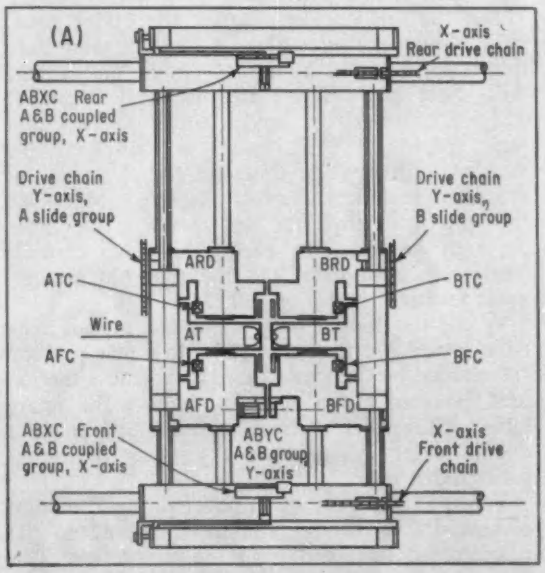
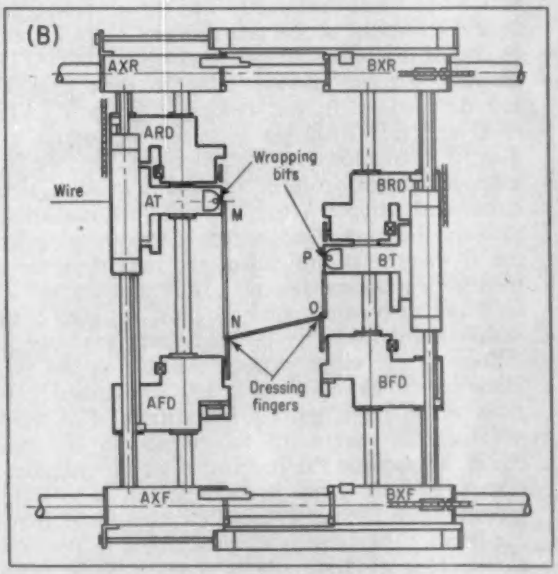


FIG. 3. Wire wrappers and dresser fingers move in a specified sequence to route and connect each wire.



SEQUENCE

1. B gripper grips previously stripped wire end.
2. Both tool groups move as a unit to locate A group over point N and group A is locked against further X axis movement.
3. B tool group moves over point O and locks against further X axis movement.
4. Both forward dressing fingers (AFD, BFD) are dropped and locked against further Y axis movement.
5. Remaining tools in A group (ARD, AT) and B groups (BRD, BT) locate over points M and P.
6. Wire is cut and stripped (trailing end of wire being installed and leading end of next wire to be installed).
7. Wrapping bits close and the wire is ready for wrapping.
8. Wrapping bits descend and wrap wire around terminal pins at M and N.
9. Dressers release wire, groups retract and tool groups rejoin.

Machine-wiring back panels

The configurations shown in Figures 2 and 3 are among 40 different patterns that the wiring machine can execute. Restrictions on patterns available are necessary—six different heads moving in X and Y directions must observe restrictions on movement to avoid traffic collisions. This is accomplished by a system of coupling all the heads together, moving them as a unit, then uncoupling and locking one portion of the unit to allow the rest of the units to move away from the locked unit. For movements along the X axis; the B carriage (BRD, BT, BFD in Figure 3) is powered and the entire A carriage (ARD, AT, AFD) moves in the X direction only while it is coupled to the B carriage. Thus, at the start of any wiring sequence, the A and B carriages are coupled. The first movement must always be along the X axis to the destination of the A carriage. The A carriage is then locked at this coordinate, after which the B carriage moves along the X axis to its destination and then locks.

To move the dressers and wrapping bits along the Y axis, both rear dressing fingers (ARD, BRD) are powered. For Y axis movement, the other tool heads (AT, AFD, BT, BFD), are towed to their destinations by the rear dressers. Once locked at destination, (for instance, locking the AT-AFD couple), the rear dressers move to their final Y axis destination. In this fashion, four tools (AT, ARD and BT, BRD for example) are located at their XY coordinates. The wire end in the B wrapper is already stripped. At the A carriage, wire is cut and stripped (stripping sufficient insulation to leave the next wire end ready for wrapping by the B wrapper at the end of the next sequence), then both wrappers descend to the programmed Z level and wrap wire around the pins. All units then withdraw and rejoin for the next wiring sequence.

Some of the wiring patterns possible on the machine are shown in Figure 4. The wiring configurations would be unreasonably restricted if it were not for other controlled movements on the machine. To increase the number of wiring configurations, the back panel is mounted on a rotating table beneath the gantry-mounted wiring and dressing heads. The table is card-controlled to position at the four quadrant points about a circle. The positions are labeled Table Rotational Positions, TRP 1, TRP 2, TRP 3, TRP 4 in clockwise progression. Priority of tool movement is dependent on the table position, and a conversion of panel coordinates to rotated table position must be made. For example, when the table is in normal position, the first movement of a sequence is to the X panel coordinate of the A tool group. But when the table is at TRP 2 (90 deg CW from normal, or from TRP 1) the first movement is to the Y panel coordinate of the A tool group to be consistent with the programmed Cartesian addresses. In a similar fashion, the signs of axis movement must effectively be reversed. Decreasing Y values at TRP 1 become increasing Y values at TRP 3 (180 deg from TRP 1).

Another limitation exists potentially in that the amount of travel available to a machine member is less than the major dimension of the back panel. This potential difficulty is removed by machine design—the chassis mounting fixture (pallet) is mounted on the table so that it can move longitudinally (in relation to TRP 1) in seven increments of 2.75 in. Wiring is thus programmed to occur in 7 different areas corresponding to the Pallet Longitudinal Positions (PLP 1 through 7).

Basic design of the machine thus permits wiring any of the 16 patterns at each of the 4 table positions, providing about 40 wiring configurations in all. Shifting the pallet permits wiring of the entire back panel, despite axis travel limitations. In all, the machine can install about 98 percent of the wires of an average panel. The two percent to be hand wired are long wires and wire different from the reel wire (shielded cable, etc.).

Machine drives and controls

Construction and drive devices for the machine can be seen in Figures 2 and 3. A chain drive attached to the axis provides motion. The sprocket driving the chain is shaft-coupled to an hydraulically-powered spur gear, the power stroke of an hydraulic cylinder being translated from linear to rotary motion by a rack and pinion arrangement that is connected to the spur gear.

Hydraulic cylinder action is governed by a servovalve. When a movement signal is read from a card in the control deck, a bridge circuit is unbalanced, which opens the servovalve. Feedback to the bridge circuit is provided by a potentiometer. When the axis reaches position, the bridge signal nulls, closing the servovalve. A locating sprag then throws in, followed by a shot pin in the carriage rails. Shot pin receivers are machined at precise 0.250-in. intervals, to accept either of two shot pins, spaced 0.125 in. apart, so that final axis location (achieved by throwing the shot pin) is accurate and independent of the servo loop. One shot pin is actuated for odd numbers, the other for even numbers. In effect, the servo controls coarse axis positioning and the shot pin arrangement final positioning on a 0.125-in. grid.

While the tool-carrying slides are moving, the table rotates and the pallet slides to a new position (if required by the control card). A geneva motion unit, powered by an airmotor, indexes the rotary table. The pallet shift is accomplished using a double acting cylinder and a gripping device on pallet index pins.

When all the tools are in position, the Z motion command is actuated. The tools descend to the programmed level and wrap the connection. Different levels of wrap on the pin are programmed when more than one wire is connected to the same

pin. The wire is fed directly from a machine-mounted spool, stripped, and cut to length. End strippings are blown into a tube and dumped to avoid having them drop into the panel being wired.

Reading proceeds from column 1 to column 72, from left to right across the card, and determines the sequence of machine actions. The first 2 columns contain the card sequence number, the last two columns contain the number of the next card. In any wiring sequence, the final controlled movement is wrapping the connection. This wrapping signal triggers the read-in of the next card number (columns 71 and 72), which is held in storage. When the next card is read, its card number (columns 1 and 2) is read and compared to the card number previously stored. If the two numbers match, storage is cleared and the machine commands (columns 3 through 16) are read in sequence. Odd-numbered card columns route the signal, even-numbered columns command movement. Column 4 sets up four machine members—the pallet, the table, and the Z level for the two wrapping bits. Subsequent even-numbered columns contain the address (in binary) of an X or Y coordinate. This address number, working through a decoder matrix, sets up a voltage proportional to one of the X or Y grid lines in this absolute system. The same address number also signals the odd or even shot pin. Odd-numbered columns address the signal to the different carriages and heads. Up to six movement commands (through column 16) may be required for some patterns; if fewer commands are needed, the control skips from the last-read column to 71 and 72, where the next card number is read.

Protection against wiring errors

Unlike its human counterpart, the machine tries to correct errors before they become wired connections. A reading fault stops the machine whenever a card is out of sequence or whenever parity fails to check (odd number of punches required in each column). For either type of fault, the remedy is simple. Out-of-sequence cards are refiled manually. Note is made of missing cards and the machine restarted. Later, this connection can be made manually or by card. If a faulty card is revealed by the parity check, it is removed and the situation treated as though the card were missing.

Though the machine rarely fails to execute commands properly, three types of execution errors are possible—XY position faults, Z position faults, and connection faults. These faults cause the machine to stop. An XY position fault occurs when a tool group fails to reach its programmed destination. Examination of the card and the machine reveals the means of correction. A Z position fault occurs when either of the tools fails to descend to its programmed Z level. This can be caused by misaligned or bent terminal pins. Connection faults are detected by failure of a wrapping tool to lift itself

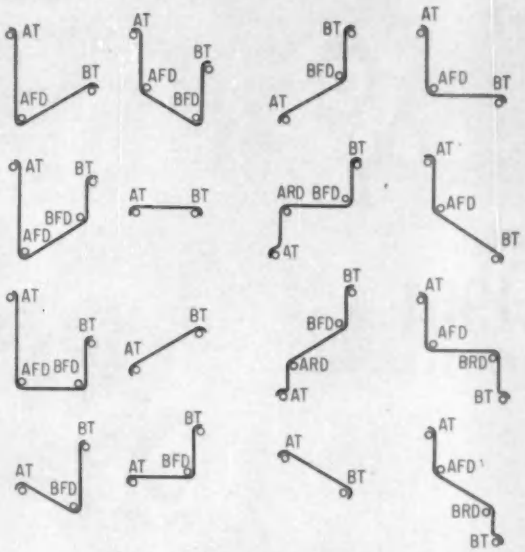


FIG. 4. For each wiring pattern, the tool slides must move in a specific order.

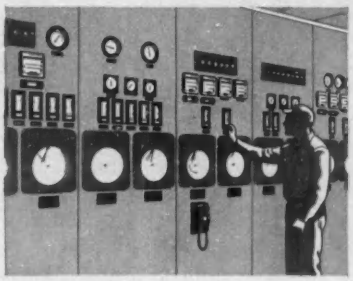
sufficiently as it wraps. This condition occurs when no wrap or a wrap with insufficient turns is made, indicating a poor or missing connection. The condition is brought about by lack of wire, broken wire, a wire dropped by either tool, tangled wire or a deformed terminal pin. Inspection reveals the appropriate correction measures.

These error prevention circuits help to reduce the occurrence of misrouted wiring and improper wiring and lessen the need to use production time for the correction of wiring faults.

DOUBLE GAINS FROM SYSTEM

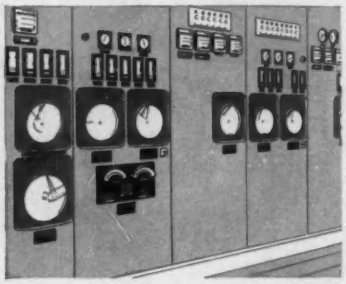
Numerically controlled wiring provides sufficient production gains over hand wiring that it is economically justifiable even when its control deck is hand prepared. With a computer program for preparing the control deck, the economic gains are increased. The wiring machine cuts down errors significantly, reducing the cost of debugging and correction of production wiring. Wiring rates are fast; a pattern is connected in 4.5 to 5.5 sec. Moreover, the machine handles design changes readily—a different card is inserted in the deck.

Computerized preparation of production documents gives efficiency to the task of translating designs into production information. Errors are reduced, lead time is reduced, and less paperwork is required. Computerized design checking and diagnosis relieves the design department of a considerable load and assists the logic designer in producing trouble-free circuitry. The combination —computer assisted design and numerically controlled wiring—is already being studied to extend the gains further in both directions. With research, the design assist programs will be able to handle more phases of design, and numerical control will handle a greater part of production.



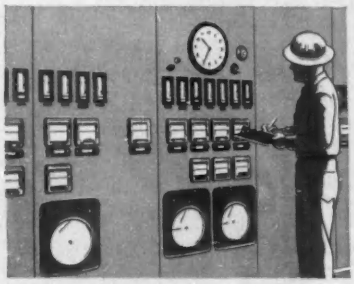
1951

Foxboro Consotrols
selected for new Celanese plant in Pampa, Texas



1952

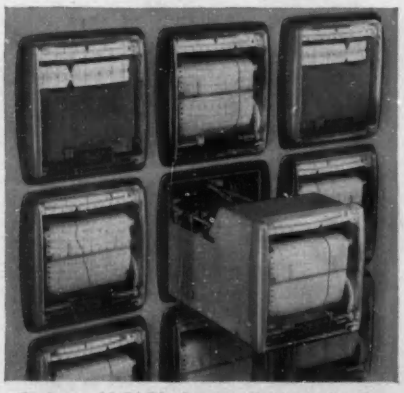
Foxboro Consotrols
selected for new Celanese special products and vinyl acetate units at Pampa



1957

Foxboro Consotrols
selected for new Celanese acrylate unit at Pampa.

. . . and now Foxboro Consotrols* major new

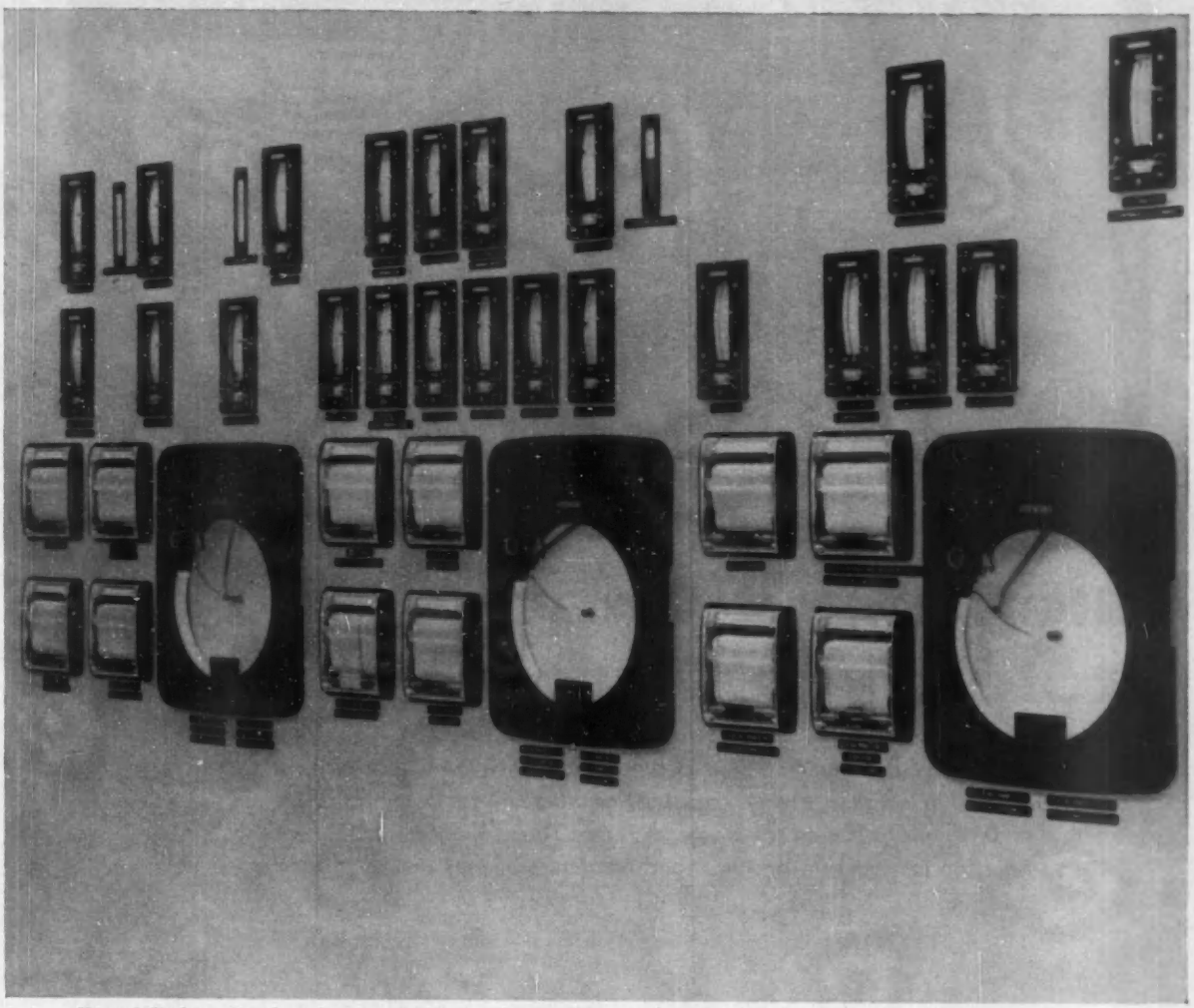


Foxboro M/54-58 Consotrol Recorder-Controllers feature full-scale 4-inch vertical-travel chart; ready adaptability to changes in processing requirements. Instruments mount on 7-inch centers for minimum panel size. Unique "floating disc" M/58 Controller has unmatched stability, sensitivity, and reliability.

Thirty million pounds of acrylates a year is the capacity of the newly-expanded petrochemical plant of Celanese Chemical Company, Pampa, Texas.

Foxboro Pneumatic Consotrol Instruments have been the nerve centers of the entire plant since the first panel was installed in 1951. Why the continued preference? M. A. Gann, Instrument Supervisor, puts it this way:

"We have over a thousand instruments in this plant. Accuracy,



Newest Foxboro Panel, designed and built by Foxboro for Celanese Chemical's Pampa, Texas plant, controls processing in new Higher Acrylates Unit. Foxboro flow, temperature, and pressure transmitters are also used exclusively.

are selected again for Celanese expansion at Pampa!

reliability, and low maintenance are absolute musts, and we've found that Foxboro Consotrols consistently deliver on all counts."

Foxboro's M/54-58 Recorders-Controllers, for example, provide repeatability of ±0.1%, complete "pull-out" convenience, and the most stable control action of any instrument in the field.

Write for Bulletins 13-18 and 13-19. Get the whole story on Consotrols. See what they can do for *you*. The Foxboro Company, 858 Neponset Ave., Foxboro, Massachusetts.

**Reg. U.S. Pat. Off.*

FOXBORO

REG. U.S. PAT. OFF.

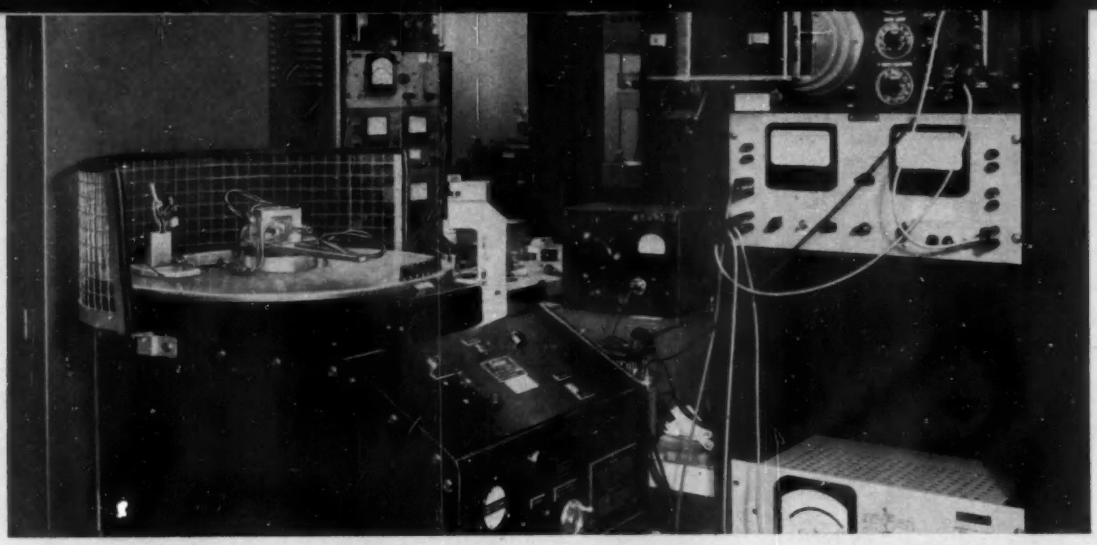


FIG. 1. Test fixture on rate table (left) stops gyro rotation and displays decaying output on scope.

Step Input Checks Rate Gyro Damping

Using the step input method described here, rate gyro damping ratios can be measured in less than 4 min. Error is under 5 percent for damping ratios less than 0.65, under 10 percent for larger ratios. The technique is ideal for both production lot checking and trial and error adjustments during production.

JOHN A. MAYNARD, Boston Division, Minneapolis-Honeywell Regulator Co.

In system applications of rate gyros, damping ratio tolerances of 20 percent over a wide temperature range are not uncommon, and 100 percent production lot testing is often essential to insure specification compliance. Usually the gyro is oscillated around its axis at controlled rates, and the gyro output is measured as a function of the oscillation frequency. The measured amplitude and phase versus input are then plotted and compared with a family of response curves (usually the theoretical second order curves) for the gyro to determine the damping ratio.

One short cut involves measuring the gyro output amplitude at essentially zero forcing frequency and at the natural frequency, and calculating ζ, the damping ratio from $\zeta = 1/2A$ where

$$A = \frac{\text{output at natural frequency at some peak rate}}{\text{output at very low frequency at the same peak rate}}$$

But even with this short cut, expensive and complicated equipment is required to supply known and controlled sinusoidal rates and to measure the gyro output, and tests are needlessly long.

Step input test method

The step method measures damping ratio while the gyro is mounted on a rate table, Figure 1. This is advantageous from a production standpoint since 100-percent rate table testing is also a requirement, and the same setup can be used for both tests. Actually, the gyro is held in a special fixture that is itself mounted on top of the table. While the table is running at constant speed, the gyro has a constant output. The operator introduces the step input by stopping the gyro-holding fixture abruptly, while the table continues to turn. The mechanism that stops the fixture also triggers horizontal sweep in an oscilloscope, and the gyro's decaying output, connected to the vertical plates of the scope, is photographed with a Polaroid camera.

If the gyro has a damping ratio of 0.65 or less, a simple measurement on the photograph of two peak amplitudes gives all the information necessary to find the damping ratio. For ratios above 0.65, two time intervals are measured instead. The picture provides a permanent record of gyro perform-

Technique adapts to low damping ratio . . .

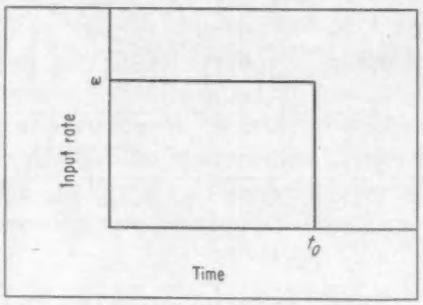


FIG. 2. Step input applied to gyro.

ance, and the entire process takes less than 4 min per gyro when damping is measured at room temperature. If measurements at higher temperatures are desired, a simple heating block can be provided around the gyro, and the test takes a little longer.

To the extent that the actual rate gyro differs from an ideal second order mechanical system, the following analysis and the method err. But tests using this method in comparison with more elaborate ones have shown less than 5 percent error for damping ratios of 0.65 and lower. The scheme employed for ratios above 0.65 is inherently less accurate, but less than 10 percent error is achievable.

Why and how it works

A rate gyro is a spring restrained, damped mass. The differential equation describing the system is

$$H\omega = I_o \frac{d^2\theta_o}{dt^2} + C\frac{d\theta_o}{dt} + K\theta_o \qquad (1)$$

where

θ_o = angular deflection of gimbal around output axis

$\frac{d\theta_o}{dt}$ = angular velocity of gimbal around output axis

$\frac{d^2\theta_o}{dt^2}$ = angular acceleration of gimbal around output axis

H = angular momentum of the gyro wheel
ω = angular rate applied around the gyro input axis
I_o = gimbal inertia
C = damping constant
K = spring constant

When the system is forced by a step input, Figure 2, the solution of Equation 1 for gyro output is

$$-\frac{H\omega}{K}\frac{1}{\sqrt{1-\zeta^2}}e^{-\zeta\omega_n t}\sin\left(\omega_n t\sqrt{1-\zeta^2}-\psi\right) \qquad (2)$$

where

$\omega_n = \sqrt{\frac{K}{I_o}}$, the undamped natural frequency

$\zeta = \frac{C}{2\omega_n I_o}$, the damping ratio, and $\psi = \tan^{-1}\frac{\sqrt{1-\zeta^2}}{-\zeta}$

The family of gyro output versus $\omega_n t$ curves in

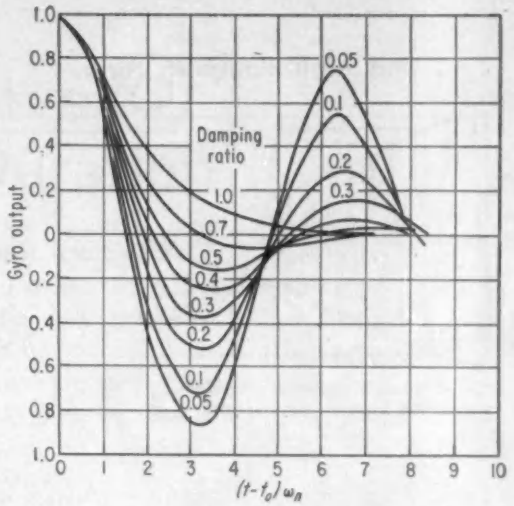


FIG. 3. Overshoot peak amplitude can be measured accurately if damping is small.

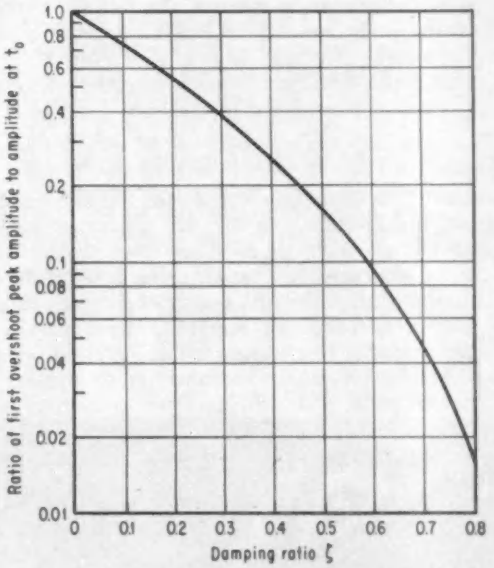


FIG. 4. Ratio of two amplitudes defines damping ratio.

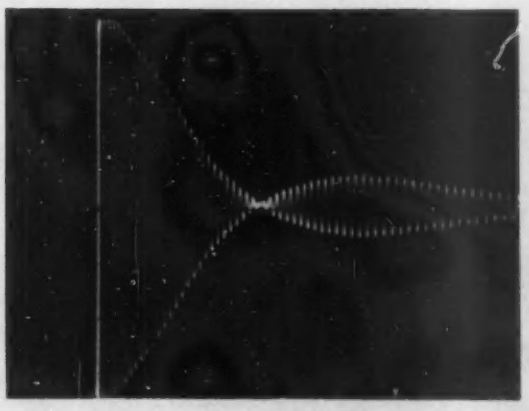


FIG. 5. Decaying output of gyro with 0.49 damping ratio.

. . . and high damping ratio.

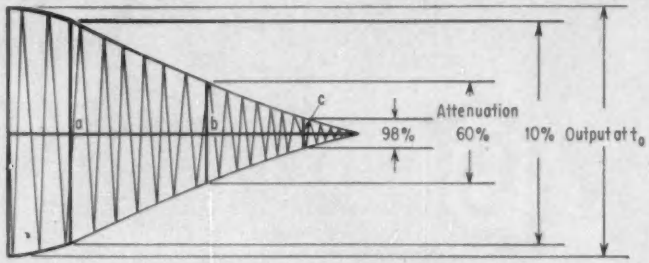


FIG. 6. In highly damped case, three attenuation levels are marked off.

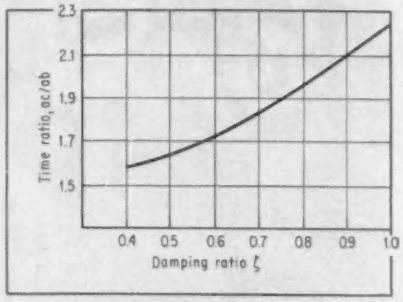


FIG. 7. Ratio of times between 10, 60, and 90 percent attenuation yields damping ratio.

Figure 3 was obtained by substituting values of ζ between 0.05 and 1.0 into Equation 2. For damping ratios less than about 0.65, the first overshoot is large enough that its amplitude can be measured accurately, and the ratio of the output at time t_o to the peak output of the first overshoot uniquely defines the damping ratio as in Figure 4. To get this curve, Equation 2 was differentiated, equated to zero, and simplified to the form

$$\cot(\omega_n t\sqrt{1-\zeta} - \psi) = \frac{\zeta}{\sqrt{1-\zeta^2}}$$

Next this expression was solved for the values of $\omega_n t$ corresponding to the first overshoot for each of several values of ζ. Then these values of $\omega_n t$ and ζ were used to solve Equation 2 to get the maximum value of the first overshoot for each damping ratio. The overshoot amplitudes were divided into the output at $t = t_o$ and the ratios plotted against ζ.

Figure 5 is an oscilloscope photo showing the output of a gyro with a damping ratio of about 0.49. Time t_o is at the left. The tester has only to measure the amplitude at t_o and at the peak of the overshoot (in any convenient units), divide the two, and determine ζ from Figure 4.

When the gyro damping ratio is above 0.65, the amplitude of the first overshoot is so small that noise and amplitude measuring errors become a problem. To overcome this, direct measurements along the time base, $\omega_n t$, are made from the photo. The ratio of two such measurements defines the damping ratio and avoids the need for careful measurement of natural frequency ω_n.

Any number of schemes can be used. One is to determine the points along the time base when the amplitude has decreased by 10, 60, and 90 percent (t_o is not used because it is hard to determine accurately from the picture). Figure 6, a sketch of the response that would be seen on a photo, shows these 10, 60, and 90 percent attenuation points. The time ratio *ac/ab* is a function of the damping ratio in a second order system. Figure 7, which shows the relationship, was obtained by solving Equation 2 for the $\omega_n t$ values that give 10, 60, and 90 percent attenuation at various damping ratios. This is less accurate than the amplitude method, because the number of measurements to be made on the photograph has increased.

Rate table modification

The rate table fixture base is made of insulating material and is solidly attached to the center of the table top. A pin on the bottom of the gyro mounting disc rests in a ball bearing in the center of the fixture base, so gyro and mount can pivot with respect to the base.

As long as a plunger is retracted, the gyro mount, along with its stop arm and counterbalance, rotates with the table top at the rate selected for the test (10-30 percent of gyro full scale rate). When the plunger holder is pulled back, the tapered plunger falls into a tapered hole in the bracket. Since the bracket is rugged and the pin fits tightly in its hole, the gyro mount stops abruptly when the arm hits the pin, while the rate table and mounting disc keep on going. With proper adjustment, friction between the mating surfaces of the discs and base guarantees that the arm will not bounce.

To avoid the need for slip ring connections between the fixture base and mounting disc, the gyro is fed directly from the table top terminals through a cable with some slack. About 2 or 3 sec after impact the plunger is pulled up, allowing the gyro to rotate with the table again.

Only coarse adjustment of sweep speed is required, but the speed should be such as to present gyro output from time t_o through the first overshoot peak for $\zeta \leqq 0.65$ or until the gyro output drops to nearly zero for $\zeta > 0.65$. For gyros with low damping ratios, this time, T, from Figure 3, is approximately $4/\omega_n$. If natural frequency is 30 cps,

$$T = \frac{4}{2\pi f_n} = \frac{4}{2\pi \times 30} = 0.02 \text{ sec}$$

With a pickoff carrier frequency of 400 cps, only 8 cycles of the carrier are displayed, and it is difficult to measure amplitude or attenuation level accurately. If the carrier frequency is 2,000 cps, the picture includes 40 cycles, and measurement is simpler and more accurate.

Magnetic Core Converts Voltage to Pulse Duration

New analog to digital converter uses low-level input voltage to set flux density in magnetic core. Switching action then generates a pulse with a time duration proportional to input level. A count of clock pulses for time interval yields number of pulses equivalent to input voltage. Since there is an individual element for each input, low-level signals do not have to be commutated and outputs can be calibrated in engineering units. This article shows how it works and describes a typical system.

V. A. VAN PRAAG, WILLIAM STANKE, and DAVID VAN MINDENO, Electro-Logic Corp.

Converting each input voltage to a corresponding flux level in a magnetic core permits the construction of special purpose low-level analog to digital converters, in which the conversion to a common pulse mode is done before multiplexing. As a result, the individual conversion devices or Transponders can be calibrated in the engineering units of the measurement and can be adapted to generate a command on input transducer failure. The low-level signals developed by thermocouples, strain gages, and similar transducers are converted into high-level high power pulses whose time duration rather than amplitude is proportional to the input voltage. Pulse counting techniques can transform this pulse duration into a three or four decimal number.

The devices are completely solid state, accurate to about 0.1 percent, and require very little power and no closely regulated voltage or current supply. The use of the magnetic core hysteresis effect permits nonvolatile storage, so that the devices can be operated in a simultaneous sample-and-hold mode without deterioration of information. Sampling speeds are up to 800 times per sec, with higher rates obtainable by using digitally interlaced output counters. Conversion to pulse duration form as close to the source as possible has several advantages: no low-level amplifiers or commutators are required, crosstalk between channels is eliminated, and multichannel systems are handled by time-shared digital equipment with an inherent accuracy of plus or minus half a count of the clock frequency.

How it works

The heart of the Transponder is a three-winding

FIG. 1. Three-winding magnetic core and its hysteresis curve.

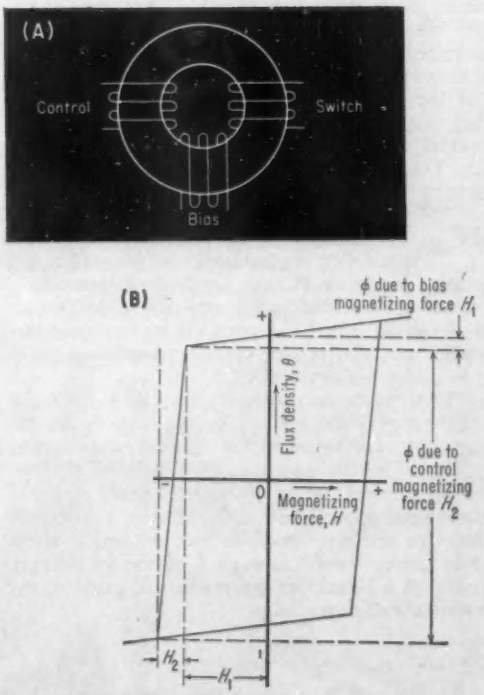
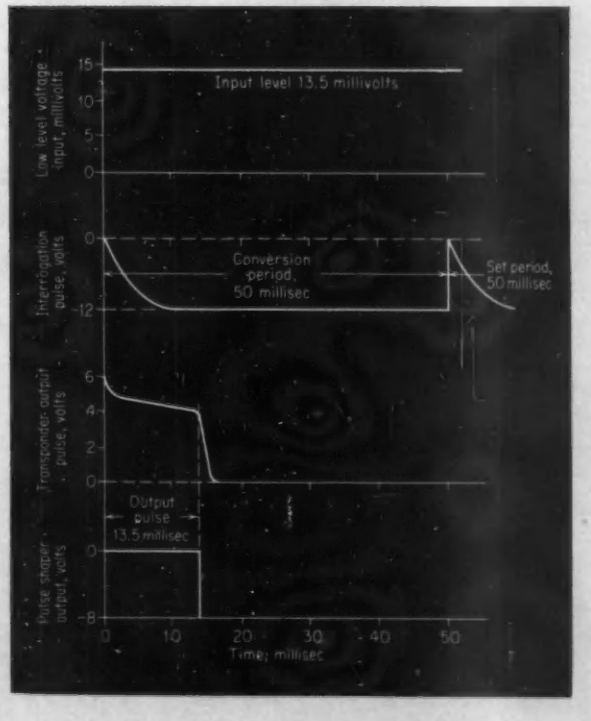


FIG. 2. Input signal to proportional pulse duration.



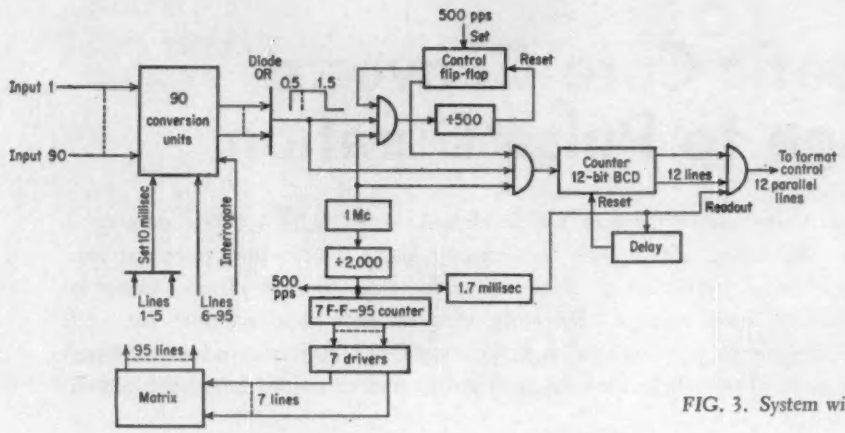


FIG. 3. System with 90 channels.

magnetic core, Figure 1A, in which the conversion is executed in two operations. Initially, the analog input applied to the control winding, with the aid of a bias signal, drives the magnetic core out of the region of positive flux saturation toward negative saturation. The analog input is sampled during this "set" mode of operation. Then the core is switched back into positive flux saturation with a signal on the switch winding, converting the analog input to a pulse duration during this "conversion" mode.

This excursion out of and back into the region of positive flux saturation is shown in Figure 1B. The bias signal applies sufficient magnetizing force H_1 to move the core out of positive saturation to the knee of the *B-H* curve. The addition of the variable input analog signal results in a proportional change in the magnetizing force applied to the core, H_2. This causes a proportional shift in flux density in the region of maximum sensitivity and linearity below the knee of the curve. Set time and control turns remain constant so that flux change is proportional to input voltage.

The switch winding drives the core back to positive flux saturation, resulting in a pulse appearing across the switch winding. The pulse is initiated at the start of the conversion period when the switch winding has a high impedance, and is terminated as the core goes back into saturation as the impedance drops abruptly at the knee of the *B-H* curve.

The sequence of events is shown in Figure 2. The input is sampled during the set period and converted during the conversion period to the irregular pulse shape shown as the Transponder output pulse. In a multichannel system this output is applied to a common pulse shaper, permitting time sharing of the output counter and control logic.

A look at some typical characteristics

The Transponder's design parameters can be altered within limits to fit the needs of each application. The permissible range of the key variables is: input voltage—100 microvolts full scale or greater; source impedance—1,000 ohms or less; conversion rate—800 cps or less; minimum and maximum pulse duration—0.5 to 1.5 millisec or greater.

These variables are interrelated by power sensitivity so that they cannot all be optimized simultaneously. Input power must never be reduced below 25×10^{-9} watts full scale or accuracy and repeatability will deteriorate. The device is basically a 0.1 percent element with a resolution of 1/1,000. Linearity is plus or minus 2.5 percent and is repeatable to plus or minus 0.1 percent. The common mode rejection is at least 80 db when applied to a balanced input. Power requirements are 150 milliwatts at 12.5 plus or minus 0.3 volts.

A multichannel system

The system of Figure 3 scans 90 channels of thermocouples and strain gages at a rate of 450 samples per sec for recording on magnetic tape in a given computer format. The 90 Transponders sample all channels simultaneously on receipt of a set pulse. At the end of the 10-millisec set period all information is in storage in the cores until it is scanned. Interrogation over lines 6-95 is at a 2-millisec rate, or 500 samples per sec. The system's speed is 180 millisec (2 millisec per channel scan of 90 channels) plus 10 millisec for the set period, or 190 millisec. Commutation is by interrogation of each device in the order desired.

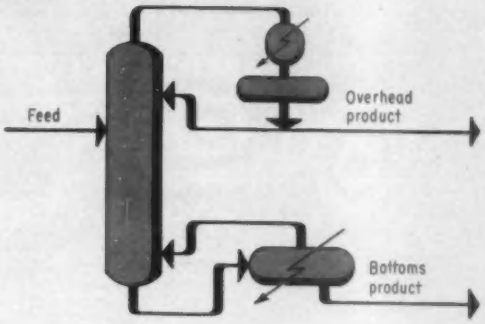
Output pulses are applied to a diode OR gate, one at a time. The pulse duration signals from the OR gate are delivered to a diode AND gate together with the pulse train from a 1-Mc crystal clock. At the conclusion of the counting period, a binary coded decimal number proportional to pulse duration is available in the counter. This can then be converted to the required format. This sequence is repeated for each channel.

For this particular system, output pulse duration varies from 0.5 to 1.5 millisec. The period from 0.5 millisec to 1.5 millisec is the information content period, corresponding to information zero (I_0) and information maximum (I_{max}). To obtain an accuracy of 0.1 percent, a 1-Mc clock rate is required to divide each 1-millisec period into 1,000 parts. If bipolar quantities are applied as analog inputs, the Transponders must be offset to count bidirectionally.

The 1-Mc clock frequency applied to a divide-by-2,000 circuit gives the 500-pps output required for the interrogation circuitry, and for readout and counter reset. The pulse train goes through a series of flip-flops to a matrix network, where 95 lines are made available. For each pulse applied to the 95 counter a successive line becomes active. The 10-millisec set period is obtained by gating lines 1 through 5 of the 95 outputs. This provides a 10-millisec pulse which is gated to the 90 Transponders in parallel.

18 Process Streams Successfully Analyzed by Chromatographs

H. J. MAIER, The Perkin-Elmer Corp.



Over 1,500 plant stream chromatographic analyzers have been installed for process monitoring and control. Once chromatograph makers develop a column for successfully analyzing a particular stream of a particular unit in a particular plant, there is a good possibility that the same column will be suitable for analyzing similar streams from other types of plants and units. For example, the components in the overhead stream of a deisobutanizer in an alkylation plant may be quite similar in composition (but not necessarily in range) to the components in the bottoms stream of a deethanizer in a natural gasoline plant.

The following tables serve as a guide to applying chromatographs. Table III, next page, classifies 18 streams—for which columns have been developed—occurring in the process units listed in Table II, which in turn are common to one or more chemical or petroleum plants shown in Table I. Such tabulations are not complete, of course, but do indicate the application information accumulated by chromatograph makers.

REFERENCE

INDUSTRIAL PROCESS CHROMATOGRAPHS, H. R. Karp, "Control Engineering", pp. 87-100, June 1961.

PROCESS PLANTS

Units	Alkylation	Butane isomerization	Ethylene	Natural gasoline
Reactor	X	X	X	
Debutanizer	X			X
Deisobutanizer	X	X		X
Deethanizer			X	X
Ethane splitter			X	
Demethanizer	X		X	X
Depropanizer			X	X

Table I—Processing units common to several chemical-petroleum plants.

STREAM ANALYSIS

(Numbers below correspond to analysis given in detail in Table III)

Units	Feed	Overhead	Bottoms
Debutanizer	7	6, 2, 3, 1, 5	7
Deisobutanizer	7	6, 2, 3, 1, 5	7
Deethanizer	12, 18, 1, 3	6, 10, 1, 18, 17, 16, 8, 15, 3, 12	6, 1, 18, 17, 16, 15, 3, 5, 12
Ethylene splitter	12, 18, 1, 3	6, 10, 1, 18, 17, 16, 8, 15, 3, 12	6, 1, 18, 17, 16, 15, 3, 5, 12
Demethanizer	18, 17	10, 18, 17, 16, 8, 14, 13	18, 17
Depropanizer	6, 5, 9, 17, 18, 16, 8	6, 1, 18, 4, 11, 14, 17, 5	6, 1, 5, 7
Alkylation reactor	Isobutane 6, 5, 9, 1, 11		
	Olefins 2, 4, 1, 3		

Table II—Chromatographs monitor similar streams in different processing units.

Table III—These streams have been successfully analyzed by chromatographs.

1	2	3	4	5	6	7	8	9
Ethane + ethylene	Ethane + ethylene	Ethane + ethylene	Ethane + ethylene	Ethane + ethylene	Ethane + ethylene	Isobutane	Air (when present)	Ethane + ethylene
Propane	Propane	Propane	Propane	Propane + propylene	Propane + propylene	n-Butane + isobutylene + butene-1	Methane	Propane + Propylene
Propylene	Propylene	Propylene	Propylene	Isobutane	Isobutane	Trans-butene-2	Ethane	Isobutane
Isobutane	Isobutane	Isobutane	Isobutane	n-Butane	n-Butane	Cis-butene-2	Carbon dioxide	Hydrogen sulfide
Hydrogen sulfide	Hydrogen sulfide	n-Butane	n-Butane	Isopentane	Isopentane	All components heavier than cis-butene-2 are backflushed but not measured.	Propane + propylene	Components heavier than isobutane are backflushed but not measured.
n-Butane	n-Butane	Isobutylene + butene-1	Isobutylene + butene-1	n-Pentane	n-Pentane		Ethylene and components heavier than propane are backflushed but not measured.	
A single peak for butylenes and components heavier than n-butane.	Isobutylene + butene-1	Trans-butene-2	Cis-butene-2	Hydrogen sulfide (will overlap propane).	Hydrogen sulfide (will overlap propane).			
	Trans-butene-1	Cis-butene-2	Trans-butene-2	Water and components heavier than isopentane (or n-pentane in some cases) are backflushed but not measured.	Water and components heavier than n-pentane (or isopentane in some cases) must be absent.			
	Cis-butene-1	A single peak for isopentane and heavier components.	Isopentane					
	Isopentane		n-Pentane					
	n-Pentane		Water and components heavier than n-pentane are backflushed but not measured. This analysis is accomplished at 65° C.					
	Water and components heavier than n-pentane are backflushed but not measured.							

10	11	12	13	14	15	16	17	18
Air (when present)	Ethane + ethylene	Ethane + ethylene	Nitrogen (and oxygen)	Air (when present)	Ethane + ethylene	Methane	Methane	Ethane + ethylene
Methane	Propane	Propane + propylene	Ethane	Methane	Propane + propylene	Ethane + ethylene	Ethane	Propane
Ethane	Propylene	Isobutane	Ethylene	Ethane	Isobutane	Propane	Ethylene	Propylene
Carbon dioxide	Isobutane	n-Butane	Acetylene	Carbon dioxide	Hydrogen sulfide	Propylene	Propane	A single peak for isobutane and heavier components.
Ethylene	Isopentane	A single peak for all components heavier than n-butane or isopentane.	Propadiene	Ethylene		Components heavier than propane are backflushed but not measured.	Propylene	
Propane (or ethane in some cases) and heavier components are backflushed but not measured.	Hydrogen sulfide will not interfere with components. Components heavier than isopentane are backflushed but not measured.		Propane	Water, propane, and heavier components must be absent.			Components heavier than propane are backflushed but not measured.	
			Components heavier than propane are backflushed but not measured.					

"a solid reliability record"

"A VIGOROUS USERS EXCHANGE ORGANIZATION"

"unmatched capability in its price class"

"WIDEST SELECTION OF INPUT-OUTPUT ACCESSORY UNITS"

"PROGRAMMING SUPPORT IN DEPTH"

"EASE OF USE!"

WITH THE BENDIX G-15 COMPUTER YOUR EXTRA DIVIDEND IS EXPERIENCE

There's a reason for the continuing leadership of the Bendix G-15 among small and medium-scale computers. The reason is *experience*... for over five years... in nearly 400 installations... in more than 1000 different applications.

Behind this experience is superior performance, real economy, and proven support... qualities which have made the G-15 preferred by thousands of engineers in industry after industry.

The G-15 achievement record is outstanding. It continues to be a leader in its field—the number of new G-15 users is growing every month. Investigate the proven capabilities of the G-15 today. See for yourself why G-15 "experience pays"... and how it can work for you. • *For information on your particular applications write to:*

Bendix Computer Division
DEPT. W-34, LOS ANGELES 45, CALIFORNIA

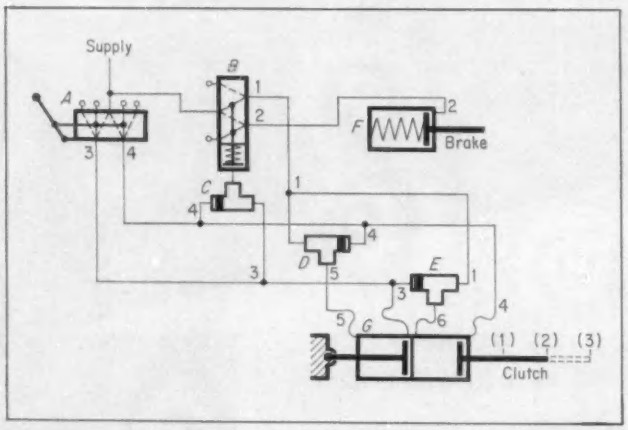
THE Bendix CORPORATION

CIRCLE 91 ON READER SERVICE CARD

Pneumatic Logic II:
AIR CIRCUITRY APPLIED

There's nothing new about using compressed air for actuation, but relatively few engineers realize the capabilities of air powered logic. Last month the author described basic pneumatic hardware and showed how a few common valve types can be fitted together to perform logical operations. Valves in series handle the AND function; valves in parallel (or the shuttle valve by itself) form an OR gate. Flow control valves regulate the pressure buildup in a volume and provide almost any time delay required. Air piloted valves in lock up arrangements can remember. The following all-pneumatic circuits illustrate how these functions can be combined to control machinery. Every one has been built and operated successfully and economically.

E. L. HOLBROOK, Barker Instrument and Machine Co., Inc.



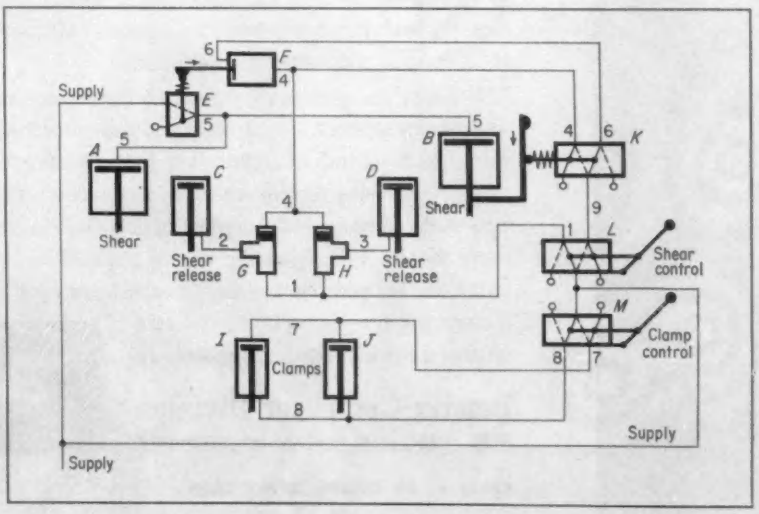
1. WINCH CLUTCH AND BRAKE CONTROL assures braking in neutral and shows one way a cylinder can provide three positions. With shift valve A in neutral as shown, lines 3 and 4 are vented to atmosphere, and supply pressure flows only through B into line 1. This pressure passes through double check (shuttle) valves D and E into lines 5 and 6, and clutch cylinder G assumes position (2). Since line 2 is vented through B, the spring in F keeps the brake applied.

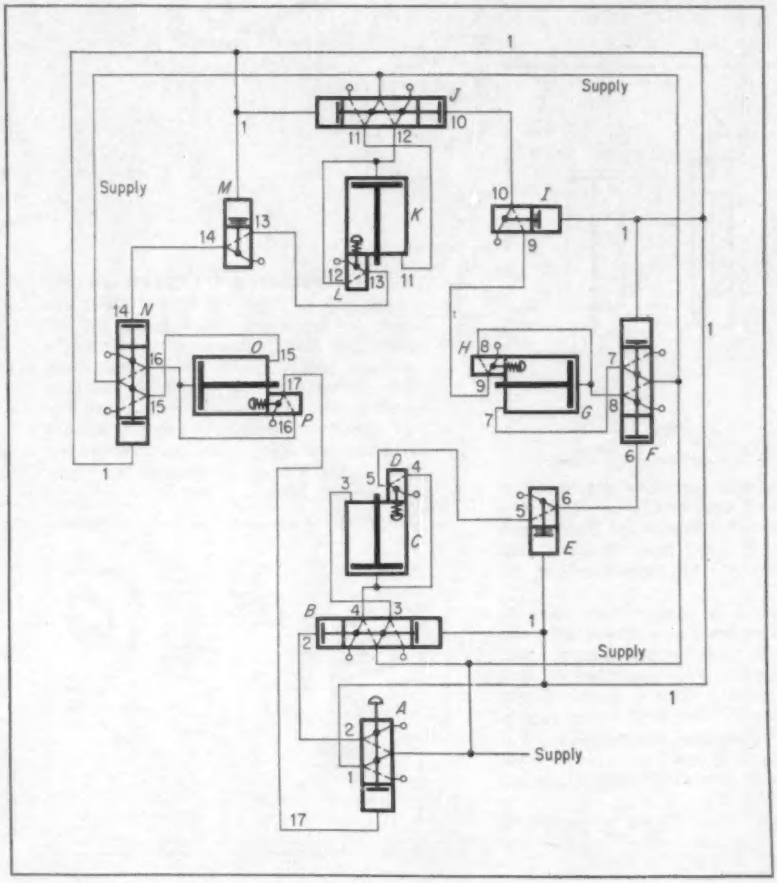
Now suppose A is moved to the left, putting pressure in line 4. This pressure pushes the shuttle in C to the right and actuates B. B vents line 1 and pressurizes line 2 to release the brake. Since 1 is vented, air in 4 can push D to the left and enter the left end of G through line 5. Air in line 4 pushes the piston back to position (1).

Shifting A to the right pressurizes line 3 and vents line 4. The pressure in 3 flows through C to actuate B which releases the brake as before. Pressure in line 3 enters G directly, as well as through E and line 6, and this puts G in position (3).

2. CLAMPING AND SHEARING SYSTEM includes air cushioning. Air routed into line 1 by L passes through G and H into lines 2 and 3 to operate shear release cylinders C and D. Lines 4 and 6 are vented so there is no pressure in cylinder F. With cam-operated valve E depressed, line 5 is vented and C and D can retract the pistons in shear cylinders A and B.

Moving M to the left vents line 8 and pressurizes 7 to push down the pistons in I and J and clamp the work. When L is operated, supply air flows through line 9, K, and line 6 to retract the piston in F. This moves the cam away from E which then admits pressure to A and B through line 5 so that the shear starts downward. Near the bottom of the stroke, the cam attached to B trips K to put pressure in line 4 and vent line 6. The piston in F then moves back to the left, actuating E and shutting off pressure from A and B. At this point air flowing down through G and H and lines 2 and 3 into C and D acts to cushion the blade.

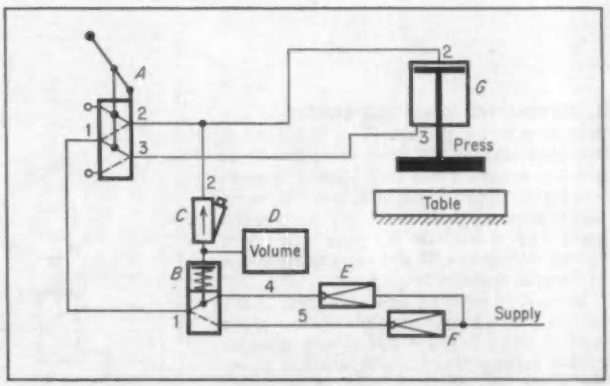




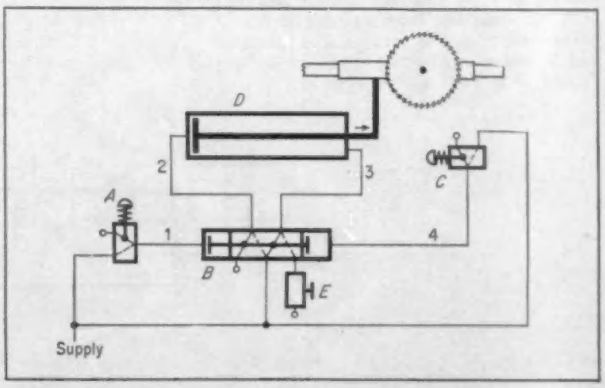
3. SERIAL OPERATION AND SIMULTANEOUS RETURN of four cylinders is started by depressing valve A to vent line 1 and put pressure in 2. Valves E, I, and M all reset, and B shifts to the right. This vents line 3 and pressurizes 4, so the piston in C moves up until it actuates D. The air in line 4 then flows through 5, valve E, and 6 to shift up F, which vents line 7 and pressurizes line 8.

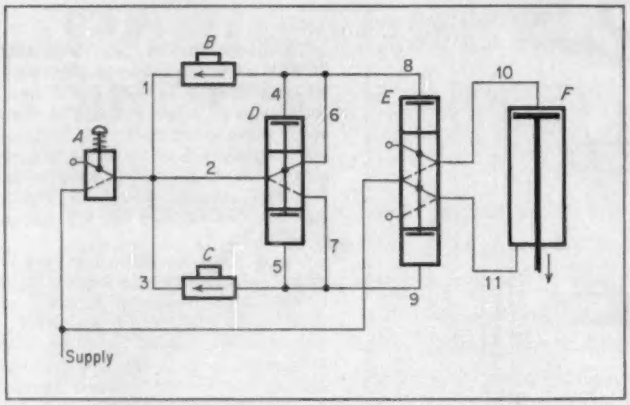
Now G moves out, actuating H and sending pressure through lines 9 and 10 to shift J to the left. J operates K, and L sends air along to shift N and operate O. As soon as P is actuated, air enters line 17 and pushes up A, venting line 2 and pressurizing line 1. This pressure returns B, E, F, I, J, M, and N simultaneously to the positions shown, and B, F, J, and N cause the four cylinders to retract together.

4. LAMINATING PRESS CONTROL applies first light, then heavy pressure. Operating 4-way valve A vents line 3 and puts low pressure from reducing valve E into line 2 and the top of cylinder G. While the material pressed between G and the table is setting, pressure in line 2 seeps through flow control valve C and into volume D. When the pressure in D exceeds the spring pressure in B, B moves to connect line 1 to line 5 and apply a higher pressure set by valve F to laminate the material. Valve E must be full internal relief type so that low pressure is restored immediately when valve A is reset and the system can be ready for another operation.



5. SAW FEED cycle is started by a momentary push on valve A. The pulse of pressure in line 1 shifts valve B to the right, putting pressure in line 2 and venting line 3 through exhaust speed control valve E. The piston in D then moves to the right at a rate determined by the setting of E. At the end of the stroke, D trips valve C to inject air into the right end of B and move B to the left (line 1 is vented). Line 2 then exhausts, and supply pressure in line 3 pushes the piston in D to the left, readying the saw for another cut.





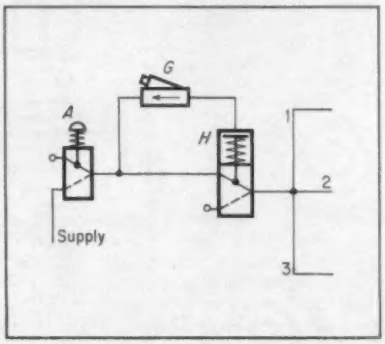
6. REVERSE CYCLE SYSTEM is designed so that successive actuations of control valve A move the piston in cylinder F back and forth. When A is pressed, air flows into lines 1, 2, and 3. The air in lines 1 and 3 is trapped by nonreturn check valves B and C; the air in line 2 flows through D into lines 6 and 8 and shifts E down. This vents line 11, pressurizes line 10, and starts the piston in F downward.

Pressure is also flowing into line 4 where it pushes down valve D, turning the supply air into line 7. If A was actuated only momentarily, the flow into line 7 is slight, but if the operator holds beyond about 0.1 sec, the lower cylinders of D and E are pressurized. Providing there is little or no leakage to deplete the pressure trapped in lines 4, 6, and 8, the balanced pressures result in no valve movement, and both valves remain in the down position when the piston in F completes its stroke.

When the operator releases valve A, lines 1, 2, and 3 are vented. Lines 4, 6, and 8 exhaust through check valve B; lines 5, 7, and 9 exhaust partly through C and partly through D and line 2.

Pressing A again causes the reverse cycle with D, E, and F returning to the positions shown.

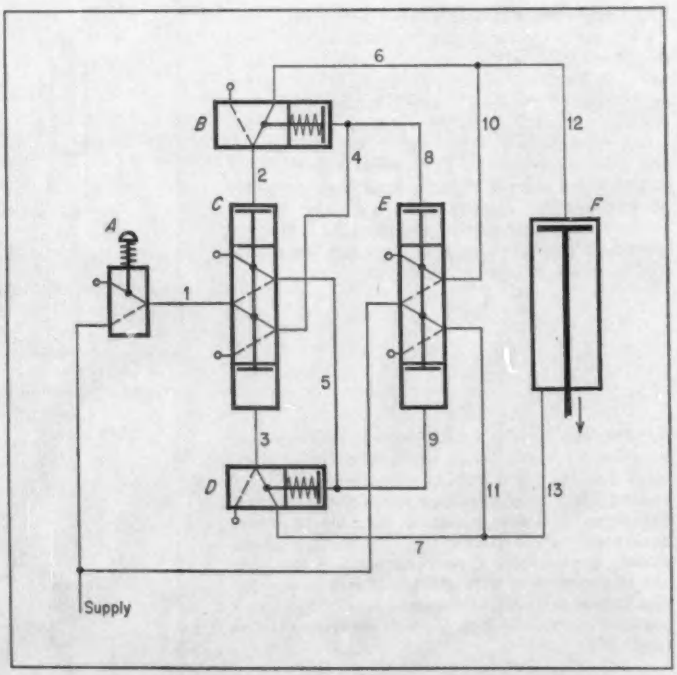
7. WHEN LEAKAGE IS A PROBLEM with the reverse cycle system, a timing device can be added to send only a pulse of air into lines 1, 2, and 3 no matter how long the operator holds A down. Here pressure flows through valve H into lines 1, 2, and 3 to perform the operation described above, but air also flows through flow control valve G into the top of H. After an interval (set by G) valve H trips, shutting off the supply and venting lines 1, 2, and 3.

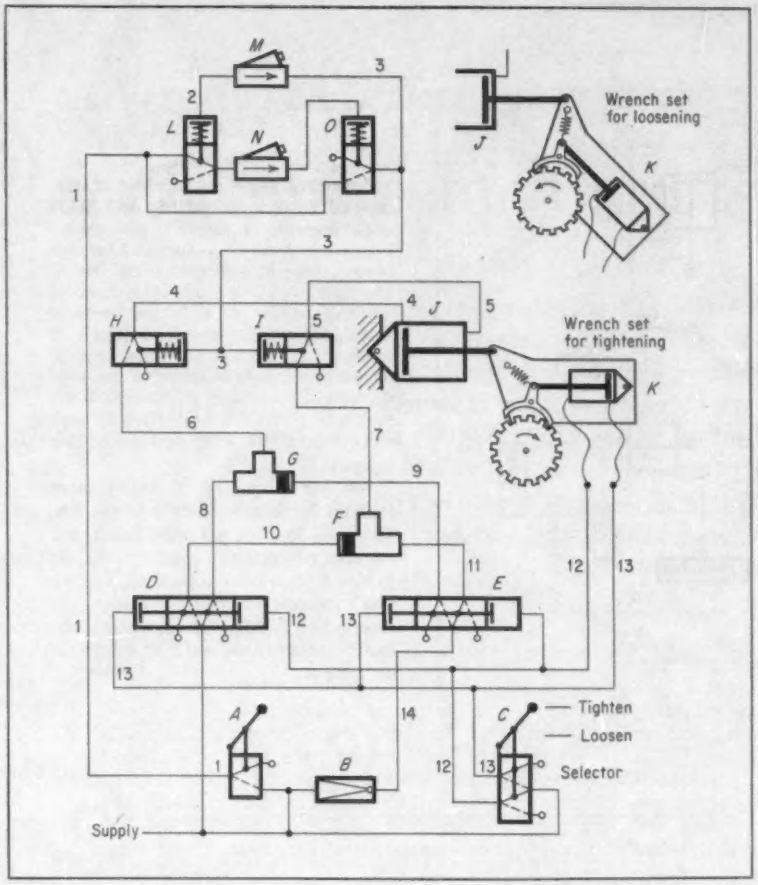


8. ALTERNATIVE REVERSING CIRCUIT is not dependent on trapped air. When the operator depresses valve A air flows into lines 1, 4, and 8 to actuate B and shift E down. B vents line 2 and the upper end of C, and E connects supply pressure to lines 10 and 12 and the upper end of cylinder F. Since line 13 is vented through line 11 and valve E, the piston in F moves down.

When A is released, lines 1, 4, and 8 are vented. Valve E does not shift because there is no pressure in line 9, but valve B releases, putting pressure from line 6 into line 2 and the upper end of C. C then shifts down, venting air from its upper cylinder and that of E, and from the upper cylinder of F.

The next time A is pressed, D is actuated and E moves up, putting pressure in lines 11 and 13 to push up the piston in F.



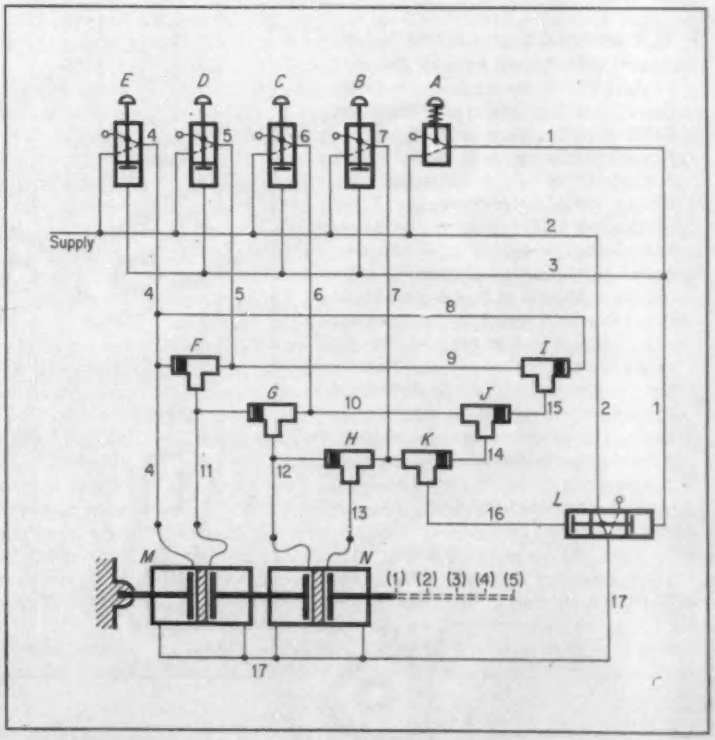


9. CYCLING SYSTEM tightens and loosens the screws of an autoclave cover with air operated wrenches. With selector valve C as shown, line 12 is pressurized and 13 is vented. D and E are both shifted to the left, and K sets the wrench rachet for tightening. Reduced pressure from B feeds through line 14, E, line 11, F, line 7, I, and line 5 to the right end of wrench operating cylinder J.

When operating valve A is actuated, it sends pressure into line 1 through L and N to actuate O. O connects line 1 with line 3, and the pressure in 3 actuates H and I. I vents line 5 and the right end of J; H puts pressure in line 4 to move J to the right.

Meanwhile the air in line 3 has been seeping through flow control valve M into the pilot cylinder of L. When there is enough pressure in line 2, L moves down, venting the left end of N. The air in the pilot cylinder of O vents slowly through N, and as soon as O moves up, line 3 is vented, releasing H and I. H vents line 4, and I applies reduced pressure to line 5 to return J to the left. At the same time pressure from line 1 flows through L and N to push O down and repeat the cycle.

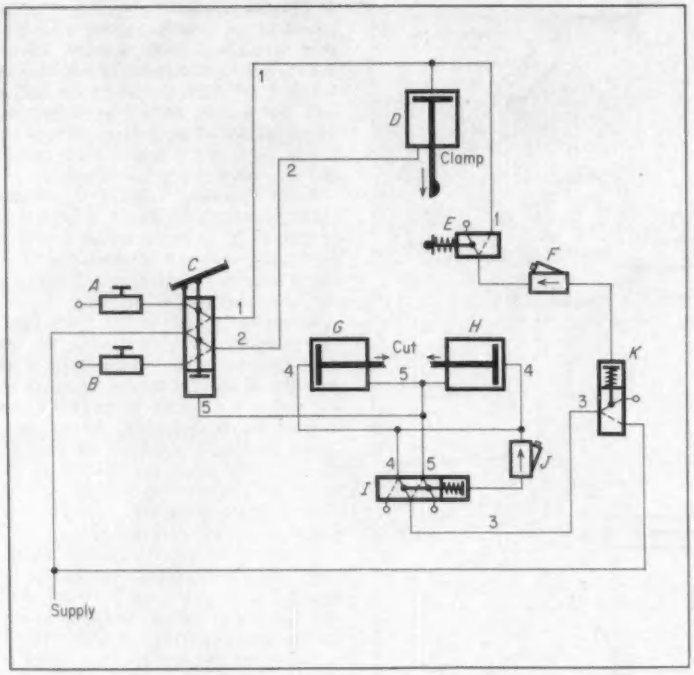
To loosen screws, C is pushed down. This vents line 12 and pressurizes line 13 to shift D and E to the right and K to the left. Now full pressure is applied to the right end of J for the loosening stroke, and reduced pressure is put in the left end of J for return.



10. CONVEYOR DEFLECTOR CONTROL puts deflector in any of five positions and keeps it there by holding air in cylinder assembly MN. As shown, A has been depressed momentarily to put supply air in lines 1 and 3, and then released. The pulse of pressure shifted L to the left and moved up B, C, D, and E. This operation set L to route pressure into line 17, returning MN and the deflector to position (1). Lines 1 and 3 are now vented, but L does not move because its left cylinder is vented through valves K and B.

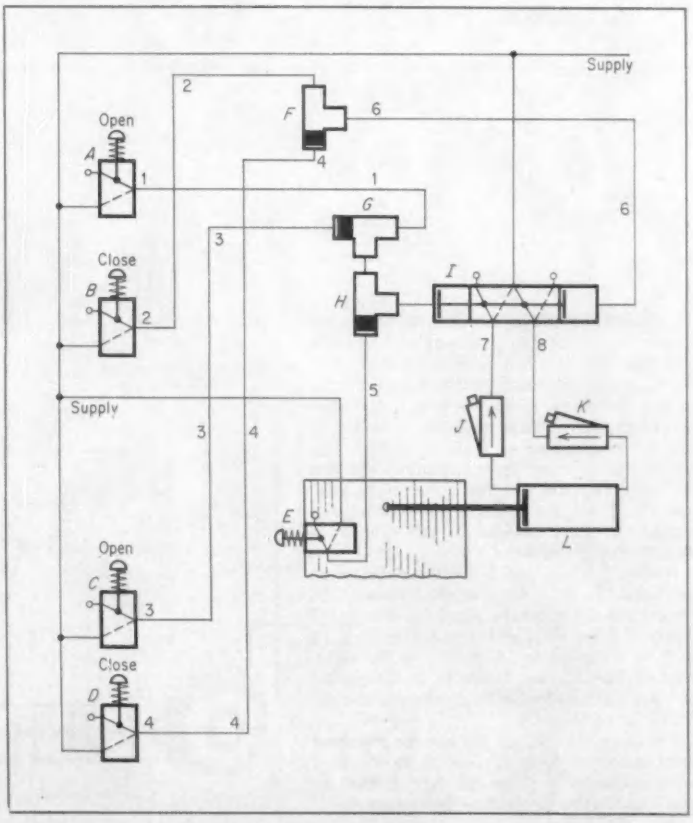
Valves B, C, D, and E put the deflector in positions (2), (3), (4), and (5), respectively. Pressing B, for example, sends air into line 7 where it flows through H and K into lines 13 and 16. Pressure in 16 shifts L to the right, venting line 17, and pressure in 13 pushes out the right piston in N and moves the deflector to position (2).

Positions (3), (4), or (5) can be attained from positions (1) or (2), but to return to a lower numbered position the system must be reset to position (1) first by depressing A.



11. MANUAL START, AUTOMATIC CLAMPING, CUTTING, UNCLAMPING, AND RESET allow operator to handle two machines. Pressing foot valve C vents line 2 through needle valve B, and pressurizes line 1. The piston in clamping cylinder D moves down at a rate set by B and operates valve E at the bottom of its stroke. B sends air to flow control valve F which allows pressure to build up in the pilot cylinder of K. As soon as K moves down, supply air enters line 3 and flows through valve I into line 4 to operate cutting cylinders G and H.

The same pressure in line 4 seeps through J and soon shifts I to the left. This vents line 4, pressurizes line 5, and retracts the cutting cylinders. The air in line 5 also shifts C back up, venting line 1 through A and putting supply pressure in line 2. K moves up immediately, and D unclamps the work at a rate set by valve A.



12. PNEUMATIC DOOR CONTROL includes door mounted safety valve E. Operating valves A and B are on one side of the door, C and D on the other. Depressing either A or C sends a pulse of pressure through shuttle valves G and H into the left cylinder of I. I shifts to the right, putting supply pressure in line 7 and venting line 8. The pressure in 7 passes into the left end of L at a rate controlled by the setting of J, and L opens the door. When B or D is depressed, air flows through F and into the right end of I, shifting I back to the left. This reverses the connections to lines 7 and 8, and the door shuts at a rate determined by flow control valve K. If something or someone is caught in the closing door, a slight pressure on the rubber edge depresses valve E, sending air through H to reset I and open the door.

A Versatile New Data Entry Device:

The Director Card System

Here is a new data entry device for input data that must contain much relatively fixed descriptive information. By using this device, such data can be coded and stored for machine read-in to reduce input errors. The Director Card System uses an 8½ x 11 in. card printed in English on the front for the operator and coded on the back for machine reading. The equipment provides a high density file from which data is quickly retrieved by the operator, plus flexibility for programmed stops at any point during read-in of fixed data for manual entry of variables.

CHARLES E. FAULKNER
Spiegel, Inc.

It is the nature of many kinds of transactions and operations that item descriptions depend upon variable formats, with often-flowery embellishments to add details. But data processing systems operate more efficiently with fixed formats and simply phrased input data. It is often necessary, therefore, to translate and edit item descriptions into simpler forms at the point of data entry. Most often this is done by human operators who make the input data conform to a specially constructed list of codes. It can also be done by highly specialized, custom designed data entry devices that automatically produce the simplified coding. But both of these solutions are seriously limited by the number of conditions covered in a coding list practical for human use, as well as by high error rates or high development costs.

Descriptive data entry problems are common to many businesses, but they are especially severe where large numbers of transactions must be entered in short periods. Typical instances are inventory control procedures for large or small scale distributing businesses, such as parts depots, wholesale and chain groceries, and hardware and apparel retailing. Airline and hotel space interrogation and ticketing or billing also involve such problems, as do banking, brokerage, accounts receivable, and sales solicitation addressing.

Spiegel, Inc. operates the largest single-location mail order house in the world at Chicago. Records of inventory on 120,000 catalog items are maintained at rates of up to 50,000 transactions per hour by an IBM 7070 computer, on merchandise items that often require statement of size and color with the plain-English descriptions on the sales slips. Spiegel, therefore, has a descriptive data entry problem of the first magnitude.

Neither of the usual solutions mentioned above would solve Spiegel's problem because of the great flexibility of description required by the mail order merchandising business. Spiegel's has had to make do temporarily with the direct manual entry of customer orders through mark-sense cards and keypunches, but too many errors are introduced by such systems, and the equipment is expensive. Because this high error rate was expected, Spiegel's electronic systems group has been planning a versatile descriptive data entry device for some years, and this month the first production models, design engineered and built by Ferranti-Packard, Ltd. of Toronto, Canada, will go into operation at Chicago. The prototypes of the Director Card System, as the new entry device is called by Spiegel, have performed better than all expectations during months of tests in actual on-line production use.

Besides flexibility of description, Spiegel placed other requirements on the data entry device. To minimize the introduction of errors by the operators, all fixed data relating to catalog items had to be machine readable without human intervention and interpretation. Only variable data, such as multiple quantities and extended prices, should be entered manually. For economy, such data should be compiled as a byproduct of another operation that would have to be done in any case. The entire order filling, inventory control, and billing procedure was studied carefully to determine what other functions the entry device might perform as immediate byproducts.

In most mail order operations, it is usual to write sales slips for items that the customer orders. The sales slip serves as a means of order filling, identifying all items that the customer has ordered, billing the order, and finally as the packing slip in the shipment of the order. Since the sales slip must contain the description of the specific items to be shipped, see Figure 1, the writing of the sales slip is the logical point for byproduct creation.

Accordingly, a printer that would automatically type the fixed information for the sales slip, with an option for manual entry of variable data and selective data recording, plus some other functions, was

DIRECTOR CARD SYSTEM AS USED AT SPIEGEL

Mail order sales slips list much fixed descriptive data from catalog. Operator selects director card from card file by item ordered, places it face up on card reader, aligns desired line number on back by use of prism. Photoelectric scanner reads code and automatically types fixed data on sales slip. Variable data is added via keyboard on printer.

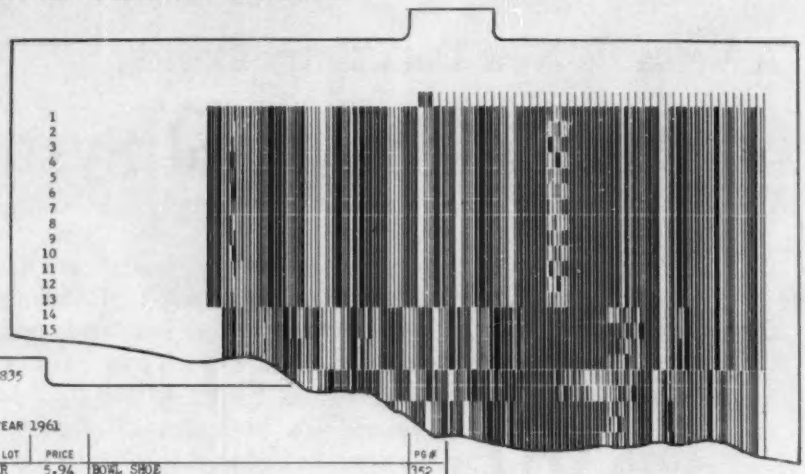


FIG. 2. English code and digital code on two sides of same card.

8835

CARD# 15 DEPT# 52 EFFORT E YEAR 1961

PR	CAT #	SF	REFER	COLOR	SIZE		LOT	PRICE		PG#
	8835				4	1	PR	5.94	BOWL SHOE	352
					4½	2				
					5	3			B/C/MED WIDTH - BILL SZ ORDERED	
					5½	4				
					6	5				
					6½	6				
					7	7				
					7½	8				
					8	9				
					8½	10				
					9	11				
					9½	12				
					10	13				
	8852			BLAC		14	EA	1.94	SHOE BAG NS - BILL BLAC	352
				TAN		15			BROWN (X) - BILL TAN	
	8855			BLUE		16	EA	1.29	SHOE BAG NS - BILL BLUE	
				BROW		17				
R	8862			BLAC/WHIT		18	EA	5.44	BALL BAG	
				TAN/WHIT		19				
R	8863			BLAC		20	EA	7.9		
				BROW		21				
R	8865			BLAC		22				

FIG. 1. Typical typed sales slip.

CUSTOMER'S SALES SLIP

IMPORTANT
SAVE THIS SALES SLIP. SEND IT TO US IF YOU WRITE ABOUT THIS ITEM OR RETURN IT.

SPIEGEL, INC.

YOU ARE BEING CHARGED OUR LATEST CATALOG OR CURRENT SALE BOOK PRICE

#	D	S.S.	CAT. NO.	SUF.	DESCRIPTION, COLOR, SIZE	LOT	QTY.		UNIT PRICE	T	WEIGHT	REQ	TAG	STAMP	CLASS	EX TAX
							ORD	SHP	●●●.●●							AMT
			R01524431		FISH OFT	EA	2	1	16RR1							
					CONSISTS OF											
			R01524430		ROD		2	1			2-		1X	1912"		
			R01524435		REEL		2	1			2-		1X	335110		

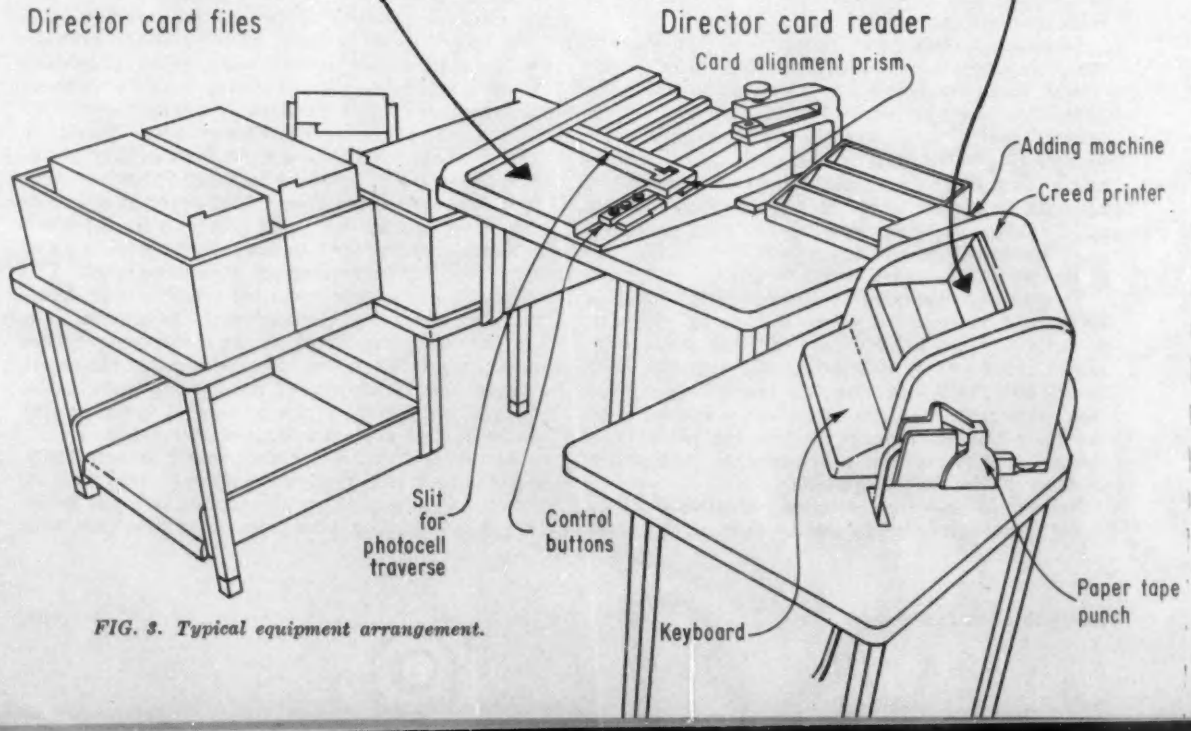


FIG. 3. Typical equipment arrangement.

the obvious answer. Some such devices are available, but they are actuated by strips of punched tape or punched cards which must be pulled from adjacent files. With over 100,000 items, the file of paper tape strips or punched cards would not be operationally practical because the size of the file would make indexing and searching too difficult. A file of a much higher density was needed.

The director card concept

The concept of the director card developed as the keystone of the new data entry system, providing economical, high density data storage and convenience for the operator. The director card, a portion of which is shown in Figure 2, has fixed data printed on the front for the operator and the same data coded on the back to be read by the machine without turning the card over. It is an 8½ x 11 in. card, printed by an offset process and die-cut at the top to provide an index tab for ready reference. The face of the card carries descriptive information in English of up to fifty-five items. Each item occupies one line on the card, arranged in the sequence of merchandse department number, catalog number, color (alphabetically), and size. About 3,500 cards will accommodate the 120,000 stock items at Spiegel.

The descriptive information is printed so that the operator, after locating the correct card by its index tab, can easily find the line upon which the specific item is represented. Each line is identified by a line number that corresponds with a line on the reverse side. The machine-readable coding, printed line for line on the other side of the card, includes all data required for typing the sales slip, plus codes for controlling the operation of the printer, a paper tape punch, and an adding machine.

Ninety-six coded characters can be printed on each line. The code is 6-bit Baudot, printed 12 characters per in. In general, the code is the normal Baudot as applied to alphanumeric characters, see table. Certain standard special characters are used as well, and others of the available 32 code configurations are assigned to program specific functions. Note in Figure 2 that the coded bits are represented by black and white lines, the lines being a full ¼ in. high and about 0.01 in. wide. Faithful printing of the coded side is easy. The problem of accurate relative positioning of the printing on the front and back is avoided because the operator aligns the director card on the reader according to the line number on the faced-down coded side by using an aligning prism in the face plate of the machine.

The complete data entry system

Besides the card reader, the Spiegel data entry system, Figure 3, includes a printer, a paper tape punch, an item counter, and a solenoid actuated adding machine.

The face plate of the Director Card Reader is set in the desk at a 10 deg angle for maximum operator efficiency. It consists of a face plate, a card alignment guide rail, the prism and reading aperture, several control buttons, a photocell reader assembly, and a solid state decoding and control pack. The alignment guide bar is mounted at the left side of the face plate because time studies indicated that this would give best efficiency. The prism assembly is positioned at the mid-point on the right side of the face plate to reflect the line numbers on the reverse side of the card as the card is shifted up or down along the guide bar.

A slit extends across the face plate from the prism. Light is projected to the coded back of the card through this slit, and a photocell assembly moves underneath on a carrier to detect the blacks and whites of the printed code characters. The detected codes are transmitted to the decoding and control pack that controls the printer and the other components.

The operator positions the card at the desired line, and if the customer has ordered a quantity of one, presses the "START" bar to cause a completely automatic typing of the sales slip. The printer will type 50 to 72 characters in a maximum of 9.6 sec. When the customer orders more than one of an item, the operator uses an optional start button and the typewriter stops when it reaches the "Quantity" column on the sales slip. The operator can then manually enter the quantity required and the extended price through the keyboard.

Another optional start button is also provided for other needs that may occur. A stop for manual fill-in can always be coded on the card for any particular item. The typing is restarted after manual entries by depressing the start bar on the reader or the "Restart" key on the typewriter keyboard, whichever is more convenient to the operator. This equipment will be used on a production basis by operators being paid on an incentive

Baudot Code Used on Director Card

Letters	Figures	Program codes	Combination program codes
A	–		Blank, K, Lttrs – Reader stop
B	5/8		
C	1/8		Blank, C, Lttrs – Optional reader stop
D	1/3		
E	3		Blank, F, Lttrs – Optional reader stop
F	2/3		
G	1		
H		Punch off	Blank, N – Alternate program
I	8		
J	¼		
K	½		
L	¾		
M	▪		
N	7/8		
O	9		
P	0		
Q	1		
R	4		
S		Punch on	
T	5		
U	7		
V	3/8		
W	2		
X	/		
Y	6		
Z	"		
		Function (Print / Punch off)	
Lttrs.	Lttrs.		
Figs.	Figs.		
Car Rtn.	Car Rtn.		
Line Feed	Line Feed		
Space	Space		

system, so it is desirable to provide the operator with controls in multiple positions.

A "Ready" light, a "Line Feed" option button, and an "Error" key round out the controls on the card reader. Automatic error detection is provided by counting the bits read and comparing the count with a check digit at the end of the coding. If the count does not check, the system locks until the error key is pressed. The error key causes three "X's" to be typed on the sales slip and an error code to be punched in the paper tape. It then returns the reader and the printer carriages to start position, and ejects the erroneous form.

It is often necessary to type multiple lines on one sales slip, Figure 1. The equipment is normally programmed to feed a new form at the end of each line, but a line feed option inhibits the form feed by simply starting the operation by depression of the "Line Feed" button. An electric item counter mounted at the top of the reader counts the number of sales slips typed for each order, and is reset by the operator when the order is completed.

The Director Card Reader is completely designed and fabricated by Ferranti-Packard, while the tables, printer, item counter, and adding machine units are of other manufacture. This permits use of standard equipment, modified only as necessary, for economy of design and lower equipment cost.

The printer and other units

The printer is a Creed, manufactured in England by a subsidiary of IT&T. It is standard equipment, equipped with a form feed device not previously offered, and types 10 characters per sec. The keyboard has the full range of numeric and alphabetic characters and includes fractions not normally provided, but required in merchandising. The printer types 10 characters per in. and 6 lines per in.

The printer does not have the "stunt box" found in American machines, but when combined with the electronic logic of the reader, it has all the necessary programming abilities at a lower cost.

Of particular interest is the tape punch mounted on the side of the printer and linked mechanically instead of electrically. The paper tape punch is used by Spiegel to record unit (item) and dollar sales information. As mentioned previously, the device is programmable by the code printed on the director card, so any desired data may be recorded on the paper tape. In Spiegel's case, 22 digits of information are required, as follows:

Department number	2*
Catalog number	4*
Code for catalog from which order was placed	2*
Quantity	3*
Price	5*
Color code	2
Size code	2
Price option code	1
Record end code	1

As the data is read by the reader, certain codes turn the punch on or off. Some of the data (marked * above) is punched simultaneously as it is typed. The last six are punched, but are not typed. The "Run-out" key on the keyboard punches "leader" and "trailer" sections of the output tape with pin feed holes only.

The paper tapes containing this data will be collected periodically during each day, spliced, and converted to magnetic tape by a Digitronics paper tape to magnetic tape converter. The magnetic tape will then be fed into an IBM 7070 for processing in the merchandise inventory control system.

Spiegel intends to use this equipment with the same director cards in other applications that will require different typing and paper tape punching configurations. This will be done by changing the logic in the Director Card Reader to respond differently to particular codes. For example, every code will be punched when the equipment is used at an outlying location in order to reproduce the order at the home plant via Teletype. A logic change that inhibits response to the "punch-off" code will meet this requirement.

At some point in the order flow, it is necessary to add the prices of the items being shipped in order to determine the total merchandise charge to the customers. Sales taxes and transportation charges are added to this total. In major mail order houses, this is usually done in a billing operation after packing of the order, just before shipment. If, however, the merchandise total can be obtained automatically as a byproduct of another operation, the billing operation will be simplified, the operation cycle reduced, and the order shipped sooner. Since the price is typed on each sales slip, byproduct addition is possible.

This addition is made by a solenoid actuated Addo-X adding machine under program control of the same impulses that cause the price to be printed on the sales slip, whether automatically or manually entered. These impulses are branched and operate in parallel, and so cause no delay. At the end of each order, the operator merely strikes the total key, detaches the adding machine tape and staples it to the order, eliminating addition at a later stage.

The system is very flexible

The Director Card Data Entry System offers many options to the operator. It is extremely flexible as used by Spiegel, and it can be flexible in configuration as well—other devices such as key punches, accounting machines, or check writers could be incorporated as required.

Besides all the business applications implied at the beginning of this article, the system could be adapted in incidental application as a paragraph writer, to write letters composed of combinations of established paragraphs with far greater input selection than is obtainable from currently available equipment. For this purpose, an automatic line-by-line card advance mechanism can be added to the reader unit, actuated by control codes that are included in each line of data coding.

Computer program instructions could also be stored on director cards to make the writing of instructions into paper tape or punched cards a rapid, routine, one-step operation without the opportunity for error that now exists. If we use imagination in the application of system configuration options, there are many more possibilities.

The State of Development of Telemetering Components

Telemetering component evaluation programs are run by Astronautics on common component types made by a number of suppliers. These evaluation programs yield comparative data useful to system designers in selecting components, and the author suggests that for this purpose there is no substitute for your own tests. But comparison of Astronautics' data with similar data taken five years ago also shows disappointingly slow progress. Future progress can be faster because system requirements for telemetering components can be judged accurately from environmental data now recorded. Much needs to be done.

C. R. CEARLEY
General Dynamics/Astronautics

The designer of telemetry systems enjoys a somewhat unique advantage in the wide range of components obtainable "off the shelf" from electronic and electromechanical equipment manufacturers. Computers and other electronic systems are sometimes built from standardized and available components such as flip-flops, gates, and shift registers. But building-block construction is even more common in telemetering system design than in computers as a result of more complete standardization in equipment.

Ten years ago there were only four recognized companies in telemetering component manufacturing; there are now more than 30. In addition, there are about 40 transducer manufacturers. The growth in the number of telemetering component vendors has come about because small companies can enter the field profitably. However, there are a few cases of large companies entering the telemetering business (Texas Instruments) or acquiring a smaller firm (Pacific Mercury, American Bosch Arma).

Instrumentation designs change frequently to meet changed measurement requirements. The small companies are better able to meet the demand for short lead time delivery of components to accommodate these changes.

Requirements for telemetering systems

The requirements that air/missileborne telemetering components must meet are generally the same as for other air/missileborne electronic equipment and include limits on reliability, environment, size, weight, power, cost, etc.

Most telemetering systems have parallel paths for information flow and can suffer many failures without complete loss of all data. Figure 1 is a block diagram for a typical airborne PCM/FM system. The "series" elements, such as the antenna and the coder, must generally be more reliable than the individual transducers and signal conditioners.

All missile systems must be able to operate in a vibration, temperature, and atmospheric environment which may be quite different from that normally found on Earth, and one major use of telemetering systems has been to determine the nature of missile environments. Unfortunately the telemetering and other systems for the first test of any new missile have had to be designed and built without the benefit of flight test data. The only thing to do was to estimate the environment from past experience and ground test data, and then add some margin for conservatism. Every telemetering symposium has included examples of ingenious solutions to problems of shock, vibration, and high and low temperatures.

Telemetering component manufacturers do not agree on the environmental limits for their prod-

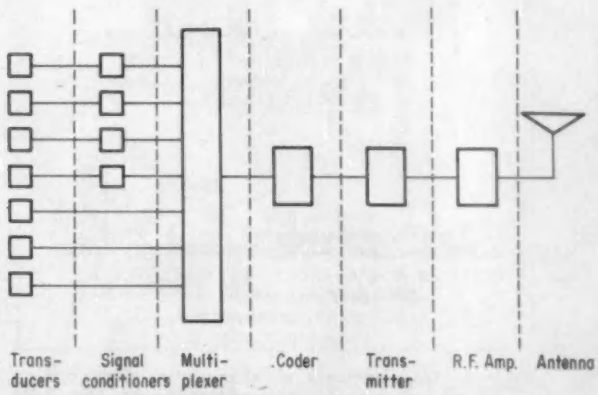


FIG. 1. Major components at transmitting end of a typical PCM/FM radio telemetering system.

TEST DATA ON 30 VOLTAGE CONTROLLED OSCILLATORS–SIZE AND POWER

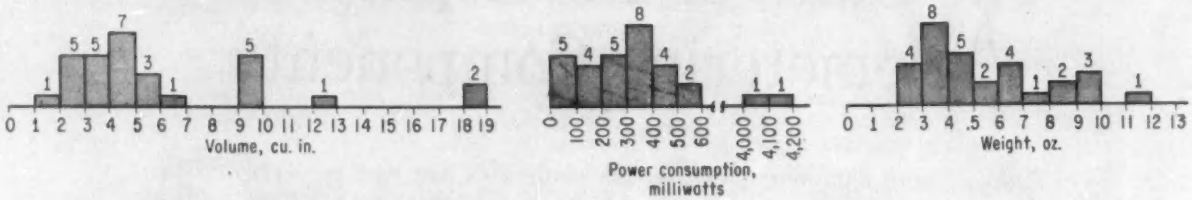


FIG. 2. Data taken on 30 voltage controlled subcarrier oscillators include 18 different types made by 11 different manufacturers. Vertical dimension is the number of oscillators which measured between the limits indicated.

NONLINEARITY AND DISTORTION IN 30 VCO's

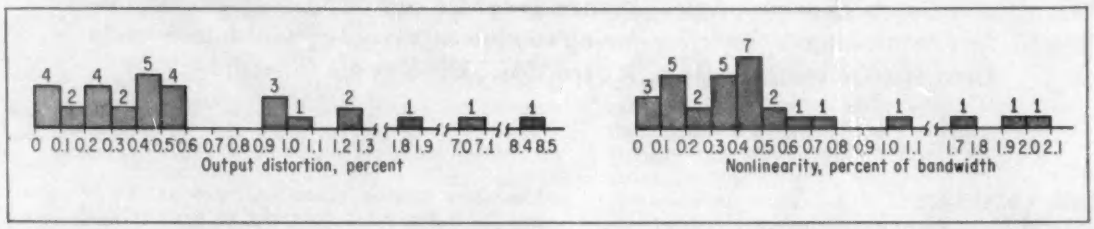


FIG. 3. Output distortion and nonlinearity measurements showed wider spread than more obvious size and power.

TEMPERATURE SENSITIVITY IN 30 VCO's (−30 to +170 deg F)

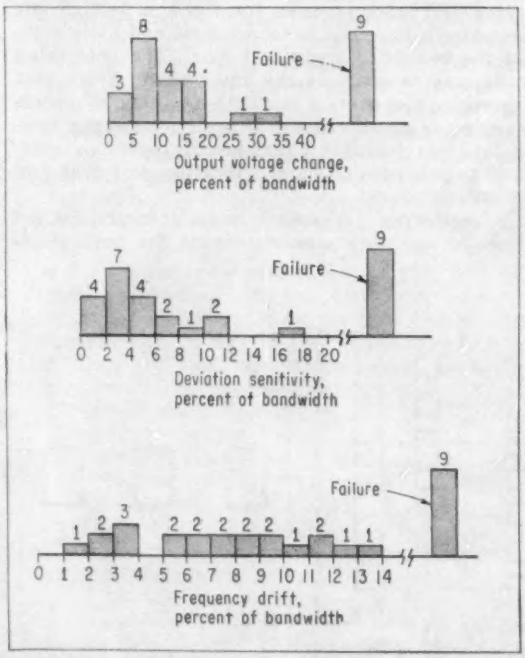


FIG. 4. Measurements of changes in three critical parameters over wide temperature range caused 30 percent of oscillators tested to fail entirely. Wide variations in most of others would make them unusable.

ucts. The average operating temperature specified for components is 0 to 85 deg C. The maximum extremes are minus 50 to plus 100 deg C. The common vibration limit is 10g's swept sinusoidal. Altitude limit claims vary with the testing capability of the manufacturer, but most components built today will operate satisfactorily in pressures from several atmospheres to a very high vacuum.

Some problem devices are blowers, rf amplifiers, and antennas. The density of the atmosphere in which blowers operate must be controlled. High voltage devices such as rf amplifiers and antennas must be pressurized or otherwise protected against corona induced by passing through ionized layers of the atmosphere. Astronautics' experience has shown that antennas must be operated at less than corona extinction (not ignition) power so corona will extinguish after passing the ionized layers.

Size, weight, and power requirements of telemetering systems vary considerably with application. Power requirements of telemetering components are important for two reasons: weight (in the power supply), and temperature control.

Electronic packages installed on space vehicles are often cooled by radiation only, although other schemes such as evaporating liquids are feasible. Fins are not too effective in reducing package size: maximum volume reduction is about 25 percent.

Component selection requires data

Consider the case of an engineer who plans to select an "off the shelf" component for use in a telemetering system. A fairly typical example is the voltage controlled subcarrier oscillator (VCO). A majority of the telemetering component sup-

pliers market such oscillators and publish specifications outlining their characteristics. The system designer may review these specifications to determine which company's product best meets his requirements. But there are two problems with this procedure: the company may fail to list certain pertinent characteristics such as dynamic linearity and data feedthrough; and, worse, the equipment provided by these vendors may not meet the specifications they do list. In selecting components there is no substitute for test data.

Astronautics has a continuing program of telemetering component evaluation. The program is relatively inexpensive because the component suppliers are usually eager to loan components for test and because the actual testing takes very little time when standard test procedures are used.

Astronautics has standard tests for each common type of telemetering component, i.e., subcarrier oscillators, rf transmitters, and commutators. Some results of an evaluation program covering 30 voltage controlled subcarrier oscillators are given in Figures 2, 3, and 4. These 30 oscillators included 18 different types from 11 different manufacturers. Besides the VCO characteristics shown, Astronautics has data on output voltage, input impedance, frequency shift due to change in source impedance, output impedance, percentage AM on output, data feedthrough, frequency response, frequency drift over a smaller (0 to 130 deg F) temperature range, deviation sensitivity change with temperature (0 to 130 deg F), and effect of vibration on center frequency, deviation sensitivity, and output voltage. Recently, a dynamic linearity test was added.

A system designer with access to such test data should find it easy to select a suitable VCO. If the designer knows that other companies are using certain equipment, he can solicit their opinions on the performance of this equipment as well.

Status of subcarrier oscillators . . .

What is the "state of the art" for telemetering components? What improvements are needed in the immediate future? The telemetering component evaluation program gives a partial answer.

A comparison of Figures 2, 3, and 4 with similar data taken five years ago shows that much progress has been made in VCO design. The average VCO

TEST DATA ON 18 TELEMETERING TRANSMITTERS

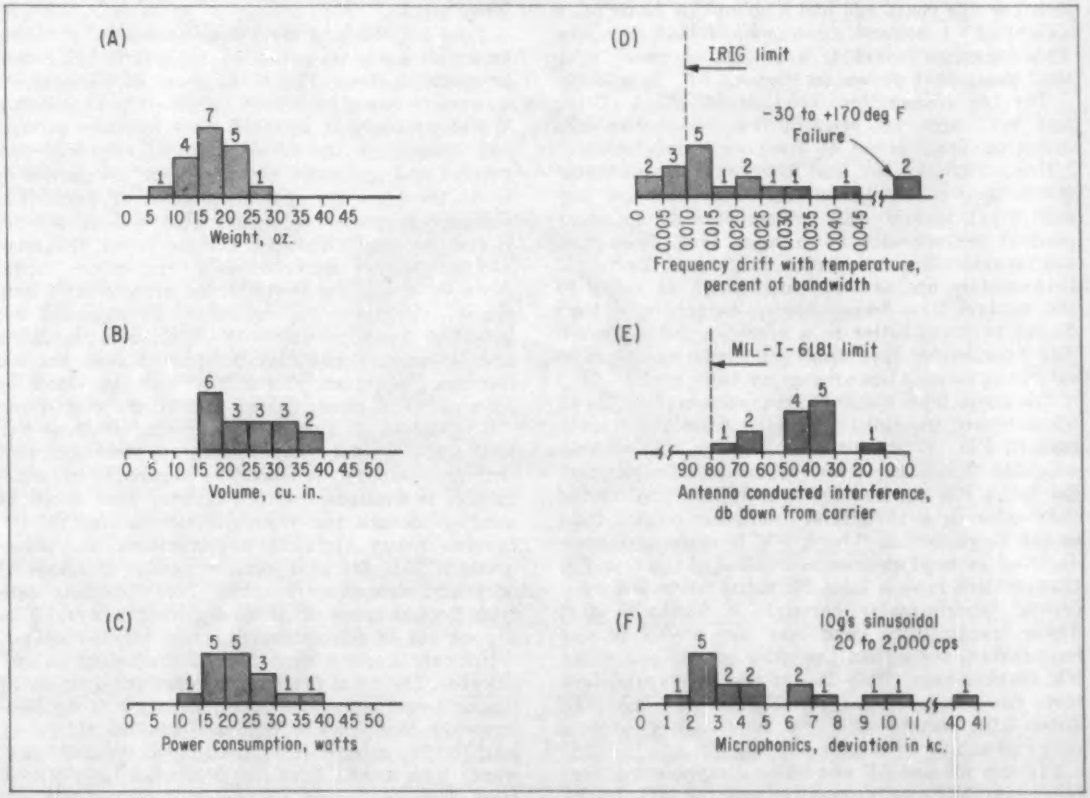


FIG. 5. Similar test data taken on 18 telemetering transmitters. All but five failed to meet IRIG frequency drift limitation, none met MIL specification on antenna conducted interference. Size and power measurements are very similar to measurements made on transmitters built 5 years ago, showing that improvement has been slow.

of five years ago weighed 8 to 10 oz, had a volume of 10 to 12 cu in., was linear only to within 1.5 to 3 percent of best straight line, and consumed 4 to 5 watts of power. The manufacturers of VCO's still have a long way to go, particularly in the area of temperature compensation. The big improvements in size, weight, and power consumption were made possible by use of transistors, and as a result the "improved" VCO of today is, in many cases, less stable with temperature change than the older vacuum tube versions. The big improvement in linearity has come about because of competition for the big VCO market. This parameter is the one most easily understood by system designers, who up till now have thought very little about other parameters such as dynamic linearity, data feedthrough, amplitude modulation, and stability of output voltage.

. . . and transmitters

Figure 5 is a compilation of some data gathered in tests of phase and frequency modulated telemetering transmitters operating in the range of 220 to 260 Mc. Eighteen transmitters of 12 types from nine different manufacturers were tested. While a great effort has gone into transmitter development in the last five years the results are disappointing. Consider that the Bendix-Pacific TXV-13 in common use five years ago had a volume of 20 cu in., a weight of 1.1 lbs, and consumed less than 20 watts. This compares favorably with data on more "modern" equipment shown in Figures 5A, B, and C.

The big transmitter development effort of the last five years has been in transistorization and changing from phase to frequency modulation.

One surprising fact that emerges from our transmitter tests is that the hybrid (transistor and vacuum tube) telemetering transmitters do not show marked performance advantages over those that use vacuum tubes exclusively. In general the hybrid transmitters are as large and weigh as much as the vacuum tube transmitters. Surprisingly, they do not perform better in a vibration environment. The transmitter type that has performed best in vibration tests is an all-vacuum-tube unit.

The move from phase to frequency modulation in telemetering transmitters results from three problems of PM. First, there is difficulty in obtaining adequate deviation at low modulation frequencies. Second, a PM transmitter is more sensitive to the harmonics in a subcarrier oscillator output than to the fundamental. Third, FM is more easily understood by most engineers. Several of the new FM transmitters have a local oscillator controlled by a crystal discriminator through a feedback loop. These transmitters have been less stable in our temperature tests than the older crystal controlled PM transmitters. Only five of the 18 transmitters tests for temperature (see Figure 5D) met the IRIG 0.01 percent stability requirement over a range of minus 30 to plus 170 deg F.

Figures 5E and 5F also show disappointing performance. Not one transmitter met the MIL-I-6181 limit for antenna conducted interference and their performance is worse when judged by MIL-I-26600.

There have been slow improvements in commutators. Mechanical units are presently available in the low speed ranges (10 rps and below) which offer low noise, low contact resistance, and moderately long life. These units are still quite heavy and fairly large. Mechanical commutators are still the best for low level signals and flexibility of application. The multipole versions have size and weight advantages over available electronic commutators. Presently available electronic commutators are best in high speed, high level applications. In the low speed applications electronic commutators are larger and much more expensive than their mechanical counterparts. Electronic commutators often have low input impedance and some feedback current to the transducer.

Improvements needed

What should be the course of future telemetering component development? For the immediate future there is plenty of work to be done in bringing the performance of components up to where it should be right now. In subcarrier oscillators, efforts should be made to improve temperature stability and some of the little known parameters such as data feedthrough. In transmitters, immediate improvement is needed in stability, microphonics, linearity, radio noise, size, weight, and power consumption. Commutators should have longer life and lower prices.

Now for the long term improvements. Planning on a national scale is needed, such as is being done on space boosters. The development of telemetering equipment has always been sacrificed to expediency. While government agencies and military services will underwrite the development of improved propulsion and guidance systems, they are unwilling to do the same for instrumentation systems. The cheapest telemetering system that will do the job is the one used. Requests for airframe, dynamics, and propulsion measurements are often turned down because, "the telemetering system can't handle it". Telemetering equipment development has benefited from advances in electronic packaging and better semiconductor components, but the big impetus for improvement has been provided by competition between the equipment manufacturers.

The design of future telemetering systems will be dictated by the measurement requirements that they must satisfy. A tremendous quantity of information is available in this country that could be used to design the telemetering systems of the future. Every airframe manufacturer has measurement lists for past vehicles sorted in terms of accuracy, frequency response, etc. Adding data from typical space probe measurements would give a good set of telemetering system requirements.

But this is only a small part of what must be considered. The total problem includes integration of tracking and command functions, as well as decisions on the development and administration of world-wide telemetering/tracking/command networks such as the Mercury, Minitrack, and NASA Deep Space networks. Without such planning, the development of telemetering components will be guided only by the press of business competition. Which isn't a bad second choice at all.

Automatic Scale Weighs Test Chamber Subjects

JOSEPH. A. FERRO
BERNARD A. JOHNSON
American Machine & Foundry Co.

Medical researchers studying the performance of a human subject in an environmental test chamber need to know how the subject's weight varies during tests that may last several days. This automatic precision scale was designed for the Aerospace Medical Laboratory's newest environmental chamber at Wright Field. The requirements are unique in that the weighing platform must be inside the chamber, subjected to temperatures from ambient to 250 deg F and simulated altitudes up to 100,000 ft, while the rest of the scale is outside. After initial manual balancing, weight changes are balanced automatically, displayed on a digital voltmeter, and printed out as a function of time. The scale has a capacity of 200 kilograms and an absolute accuracy of 5 grams.

The scale, Figure 1, comprises a 10:1 arm ratio beam balance, load and weight pans, a hydraulic seal and supply, the automatic balancing system, and recording and display equipment in a separate console. The load pan, suspension rod, short arm, and main pivot are subjected to chamber environment. A major design problem was provision of a chamber seal that would isolate the inner and outer environments without affecting scale accuracy. This isolation is provided by a hydraulic seal at the main pivot where friction has the least effect. Heat flow to the pivot from the chamber is minimized by a low conductivity suspension rod and water cooled baffles in the standpipe.

The beam rests on knife edges machined on the ends of a solid shaft. Clearance between the shaft and its housing is 0.002 in., and the shaft ends extend into openings in the ends of the housing. When the chamber pressure is less than atmospheric, oil flows through the clearance and serves as a barrier to prevent ambient air and moisture from entering the chamber.

The automatic balancing system, Figure 2, keeps the scale balanced by varying the length of 16 loops of precision chain suspended from the weight pan end of the beam. The chains are driven by sprockets, attached to a single drive shaft.

Weight unbalance is detected by a pair of photocells that views a light source on the other side of the scale pointer. When the scale is in balance, the pointer straddles the two photocells so that they are illuminated equally and have equal outputs. When the scale is not in balance, the pointer lets more light fall on one cell than the other, so for small unbalances the output difference is proportional to the magnitude of the unbalance and of the same polarity. For large unbalances, it is constant.

The photocell outputs drive a transistor amplifier through a null zone network that inhibits control action until the unbalance exceeds 2 grams. The amplifier controls a polarity sensitive relay that operates a bidirectional drive motor coupled to the chain drive shaft through one of two clutches. The low speed clutch engages automatically when the power is turned on. The high speed clutch engages whenever the beam contacts a mechanical stop that restricts beam motion to $\frac{1}{8}$ in. (about ± 12 grams unbalance). Thus, when a large unbalance occurs, usually due to motion at the load pan, the balance chain is driven at high speed until the beam moves from the stop. Then the low speed clutch takes over, reversing the chain drive and stopping the beam at the balance point.

A precision potentiometer is directly coupled to the chain sprocket, and its shaft position, indicated by a digital voltmeter, gives a direct measure of the weight introduced by the automatic system. The voltmeter and the pot are excited by a common voltage source to eliminate the need for absolute voltage calibration. An adding machine type printer records the weights along with the times (in hours, minutes, and seconds) at which measurements are taken.

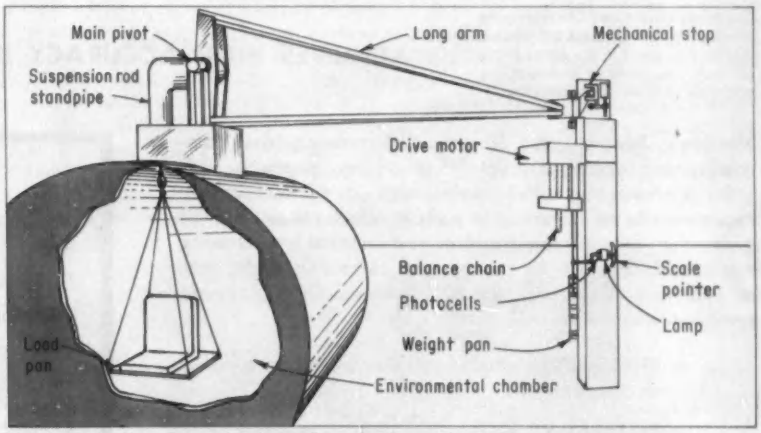


FIG. 1. Hydraulic seal at main pivot isolates chamber environment.

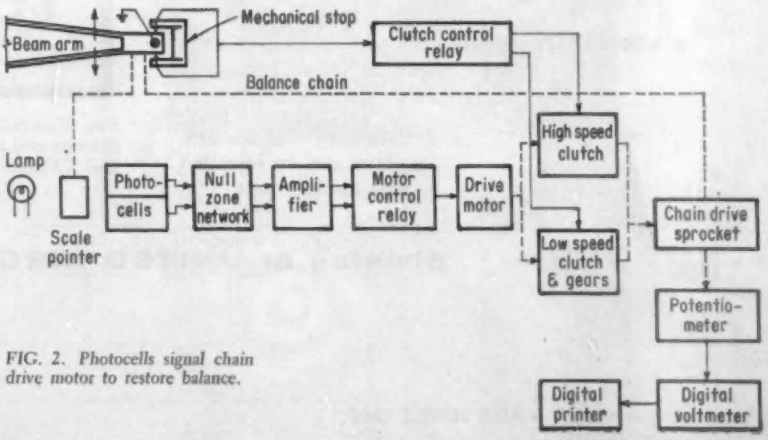
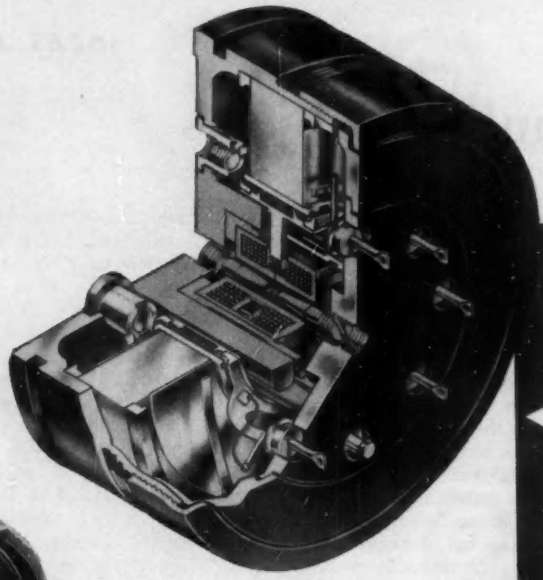


FIG. 2. Photocells signal chain drive motor to restore balance.



Originally conceived for Norden's miniature, all-attitude 20-pound platform . . . and flight-tested for 15 months. Now in production and available on short delivery.

NORDEN

INERTIAL COMPONENTS

NORDEN MINIATURE SINGLE AXIS ACCELEROMETER

ACHIEVES HIGH ACCURACY IN A COMPACT PACKAGE

Norden's force-balance linear accelerometer, with discriminating single axis detection system, provides high order precision in a miniature package . . . fulfills exacting requirements for accuracy in such applications as: inertial systems, missile instrumentation, and antenna level sensing equipment. Proved in the rugged 15-month flight test of Norden's 20-pound inertial platform, this advanced accelerometer design offers:

- **THRESHOLD**—single axis detects changes as small as 1 second of arc.
- **RELIABILITY**—translatory motion of proof mass reduces cross-coupling and susceptibility to rectification.
- **VERSATILITY**—range and performance characteristics can be varied by changing amplifier components.
- **FLEXIBILITY**—sensor and amplifier can be installed in separate locations.

TYPICAL SPECIFICATIONS

Weight	8.0 oz.
Size	2 x 0.875 in.
Threshold sensitivity	5×10^{-6} g.
Operating range	±10 g.
Range	2—20KC
Output	Direct Current
Linearity	
10^{-4} to 0.2 g	10^{-4} g (max. deviation)
0.2 to 1.0 g	0.015% of actual value
1.0 to 10.0 g	0.03% of actual value

For illustrated literature, containing complete specifications and performance data, on this and other models, call TEmple 8-4471, TWX NWLK 21, or write to . . .

NORDEN

division of UNITED AIRCRAFT CORPORATION

NORWALK, CONNECTICUT

The control system is nonlinear in that on-off control is used, and a computer analysis was conducted to determine the best characteristics. For small unbalances, the scale alone acts as a lightly damped second order system with a period of 6 to 12 sec depending on the load. If no compensation were added to the automatic balancing system, it would take about 5 min for oscillations to damp out. The scale would probably never reach a balanced condition because of subject movement. A simple lead-lag network is of little help, but a second order compensation network sensing acceleration proved effective in damping the oscillations. With the optimum network characteristics found from the computer study, the scale reaches balance within 5 sec after a 12-gram unbalance. The time required to reach balance after a 500-gram weight change is 8 sec.

Grading Transformer Sheets Continuously

F. H. BAER, McGraw-Hill News

A batch of alloyed steel sheets for transformers and dynamos can vary as much as 10 percent in thickness and 30 percent in core loss. Novel grading equipment worked out by J. Kanabe of the Electrical Machinery and Cable Works of Budapest measures both thickness and core loss right on the production line. It does away with random Epstein testing, handles 2-5 metric tons of material per hour, and allows checking the whole production. Sheets can be 750-1,000 mm wide, 0.35-0.5 mm thick, and any length. Core loss is indicated directly in watts/kilogram with an accuracy better than ±5 percent, half the permissible standard. The electromagnetic thickness gage indicates in five ranges. It also keeps the induction constant as sheet thickness varies, and automatically compensates the core loss readings for weight variations.

Core loss (caused by hysteresis and eddy currents) is proportional to the area inside the material's hysteresis loop. If the magnetizing current is sinusoidal, the loss can be found by measuring the magnetizing power. The grader has exciting and measuring coils, Figure 1, that surround the test sheet, and low magnetic resistance yokes that form a shell type core with the sheet as the excited limb. Small air gaps between the yokes allow the sheet to move. The exciting coil is driven by an electronic power amplifier with negative feedback and low output impedance to insure sinusoidal excitation of constant amplitude. A Wien bridge RC oscillator drives the amplifier, and both are run from a stabilized supply to make the excitation amplitude and frequency independent of ±15 percent line voltage fluctuations and frequency changes. Power is measured with a compensated electrodynamic wattmeter connected across the measuring coil.

Sheet thickness and width variations have a twofold effect on core loss measurement: Any variation in the cross-sectional area of the sheet alters the preset induction value and also changes the indicated loss as a function of weight. The designers felt that the width variation allowable by specifications was too small to influence the gaging accuracy. But the standards allow ±10 percent variation in thickness, and experiments showed that the measured core loss varied with more than the second power of the thickness deviation.

The electromagnetic thickness gage provides an output signal proportional to the difference between the actual and standard thicknesses. The gage consists of two sets of four air gapped coils each. The cells in each set are paralleled and connected in series with a resistance across a stabilized ac supply. A standard thickness sheet is fitted into the air gaps of one coil set, and the test sheet passes through the other set of gaps. The voltages appearing across the coil terminals are combined to obtain a voltage proportional to thickness deviation.

Besides giving an indication of thickness, this deviation signal adjusts the impedance inserted between the

FIG. 1. Sheets pass through thickness gage and core loss coils.

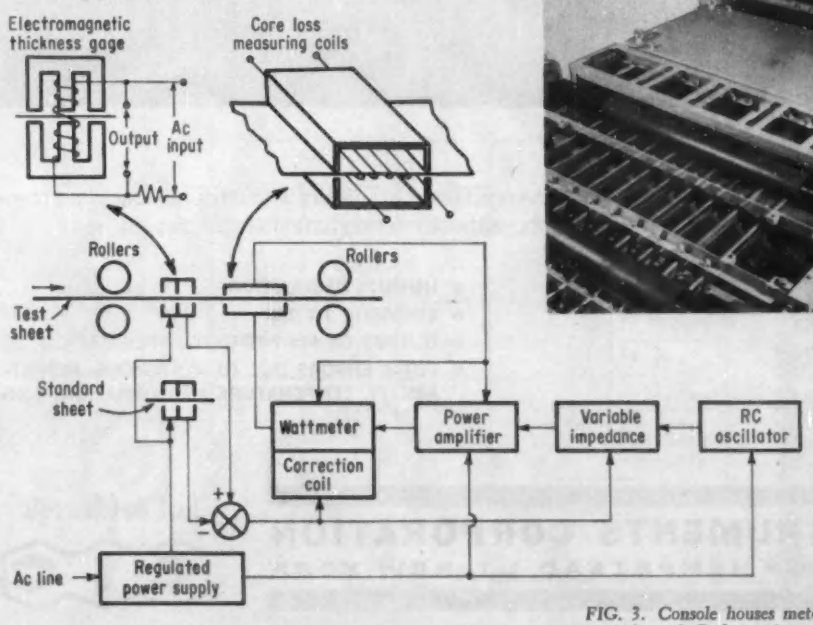


FIG. 2. Yokes are in closed compartment, thickness coils directly in front.

FIG. 3. Console houses meters, controls, and all electronics.

the world's most accurate and reliable potentiometer **pressure transducer**

The mating of advanced aneroid sensors with ultra-reliable film potentiometer elements, without intermediate linkages, results in:

- **INFINITE RESOLUTION**
- **LINEARITY TO 0.3%**
- **OUTPUT TO 40V WITHOUT AMPLIFICATION**
- **TOTAL ERRORS DUE TO HYSTERESIS, REPEATABILITY, TEMPERATURE AND VIBRATION: 0.2%**

Send for Catalog

COMPUTER INSTRUMENTS CORPORATION
92 MADISON AVENUE • HEMPSTEAD, L. I., NEW YORK

"first in film pots"
CIC

CIRCLE 108 ON READER SERVICE CARD

core loss oscillator and power amplifier. This variable impedance can be a moving coil mounted on a common shaft with a meter connected across the deviation voltage. The correction for weight is executed directly by applying the deviation voltage to a zero center instrument mounted on a common filament with the wattmeter.

The grading equipment consists of two separate units—a rugged test stand, and an instrument and control console—connected by a 10-conductor cable. The core loss measuring yoke is centered on the test stand, and the thickness measuring coils are directly in front of the yoke, Figure 2. Rubber covered rollers driven through reduction gears by squirrel cage induction motors move the sheet material through the coils and yoke at 0.24, 0.31, or 0.5 meters per sec. Five colored lights on the console, Figure 3, correspond to five thickness ranges.

Cycle Timer for Pilot Plant Control

M. O. GERNAND
Esso Research Laboratories
Humble Oil and Refining Co.

Highly instrumented pilot plants can increase research productivity by saving time, reducing human errors, and using manpower more efficiently. Rather than attempting to design pilot plants for completely automatic operation, human evaluation of run progress and processing of workups is generally retained. But manpower needs for pure control functions have been minimized by the design of equipment such as this cycle timer for automating cyclic and start-run-shutdown operations in small pilot plants. Seven of these units are in use at the Baton Rouge Esso Research Laboratories.

The timer, Figure 1, is housed in a standard temperature recorder instrument case. On the panel are controls for 10 timed channels, and each channel has two rotary switches for selecting the time interval. Time intervals from 1 min to 2 hours in 1 min steps are selected by setting the two switches so that their product equals the time duration desired for that channel. Each channel also has a hold position that locks the operation on that channel. Of course, fewer than 10 channels can be used by setting the unneeded channel switches to zero. Lights show which channel is active.

Other features include a safety channel button that switches the timer from any channel to a home position indicated by the center light. This safety channel can be set up to produce a safe plant condition. The timer can also be connected to the plant alarm system so that a signal from the latter sends it automatically to the safety channel. A single cycle switch sets the timer so that it completes one cycle and then stops in the safety channel. Alternately, this switch selects continuous cycling through the program.

In operation, the timer counts pulses from a 1 rpm synchronous motor and matches the accumulated count against the preset total time. Counting is done with relays. When a match is obtained, the timer activates the next channel.

By itself the timer can only handle a single circuit for each time period. But pilot plants often require operation of more than one circuit at a time, and a given circuit may have to be activated during more than one time period. A patchboard matrix, Figure 2, mates the timer to the plant requirements. Diode plugs inserted into the phone jacks, Figure 3, join selected control circuits to appropriate time channels. The vertical rows of jacks correspond to circuits and the horizontal rows to channels. Any circuit can be connected to any channel by inserting a plug, so changes in plant operation are readily made. Buffer relays in each control circuit isolate the timer power supply from the power supplies for the valves, heaters, and other controlled elements.

FIG. 2. Diode plugs and matrix interconnect channels and control circuits.

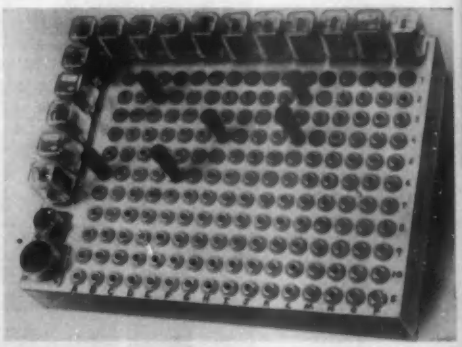
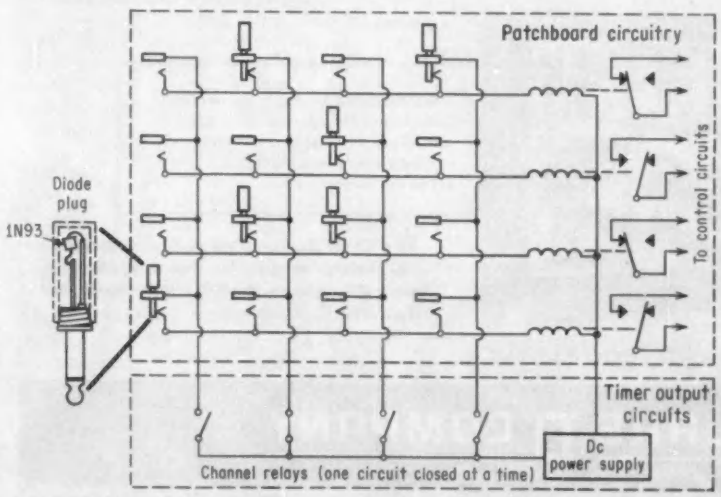


FIG. 3. Buffer relays isolate control and switching circuits.



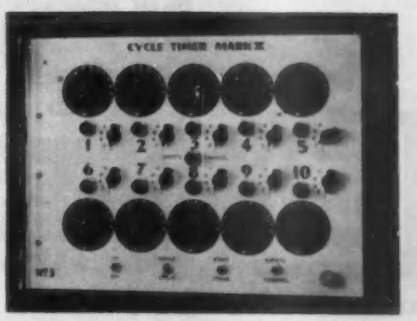


FIG. 1. Rotary switches set up time durations for each of ten channels.

SQUARE D NORpak

—A SIMPLER, FASTER, STATIC CONTROL!

NORpak is a significant advance in the field of static switching. Like other static systems, **NORpak** performs the functions of machine tool relays, stepping relays, latching relays and timers —all without contacts or motion of any kind.

Like other static systems, **NORpak** is ideal for applications where speed is important—where reliability and long life are essential—where conditions make conventional magnetic devices impractical.

But unlike other static switching systems, NORpak offers these important advantages

EASIEST TO APPLY

The transistor NOR unit is the basis of **NORpak.** All logic functions—AND, OR, NOT, MEMORY—can be accomplished with combinations of this single NOR unit.

NORpak is *not* complicated—it's easy to apply to conventional circuits. Units are color-coded for quick identification. Simple DC circuit eliminates worry about phase relationships.

UNMATCHED SPEED

NORpak provides switching at rates up to 25,000 per second—faster than any other industrial static system.

SMALLEST COMMERCIAL PACKAGES

NORpak is available in the form of individual components, or in completely engineered systems. Components are offered in 6 and 20 paks, require only 1/4th the equivalent relay panel space, and weigh less than components of other static systems.

EXTRA DEPENDABILITY

NOR units have been time-tested in computer use for years. They are not subject to wear, will give top performance indefinitely, and provide unfailing circuit fidelity.

SIMPLE TO USE

Optional monitor lights give visual evidence of proper performance. Simple dynamic sequence tester checks individual NOR units in operation.

EXPERT APPLICATION HELP

Field specialists, factory-trained in all aspects of **NORpak** can give you on-the-spot answers to any application questions.

NORpak is available as individual components for application to specific control functions, or as completely engineered systems ranging from the smallest to the largest panels

Write for the complete story on **NORpak** *—its theory, application and operation... Square D Company, 4041 North Richards St., Milwaukee 12, Wisconsin*

...design leadership

SQUARE D COMPANY

wherever electricity is distributed and controlled

Digital Actuator Positions Recording Heads

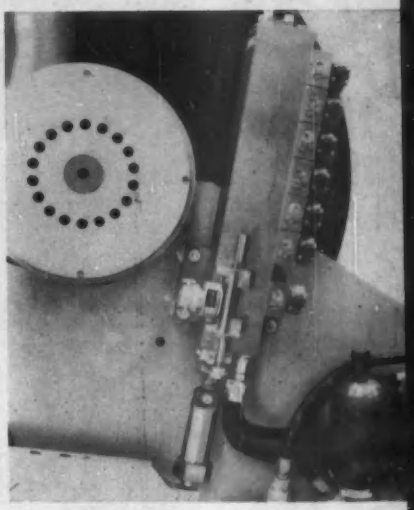
WILLIAM H. FAHRINGER
Bryant Computer Products Div.
Ex-Cell-O Corp.

An open-loop mechanical-hydraulic linear actuator in the new Bryant Series 4000 magnetic disc files positions all recording heads in a maximum of 100 millisec including settling time. The files themselves have from one to 24 discs, with total capacity ranging from 30 million to 720 million bits. For each disc face there are six air-floated magnetic heads mounted on a rocker arm so that each head can serve 128 tracks. All the rocker arms are locked together and moved as a unit through a backlash-free linkage. The actuator swings all the heads simultaneously to any of 128 positions with an accuracy of better than 0.001 in.

The actuator housing, figure, contains seven separate piston and cylinder assemblies in a common bore. Each piston pushes against the cylinder in front of it, except the seventh piston, which is connected to the load. Piston movements are controlled by seven electrically operated transfer valves. These are of standard two-stage design, with hydraulic amplification but with the feedback function eliminated.

Supply pressure working on part of the area of the seventh cylinder loads the first six piston and cylinder assemblies toward the retracted position, and supply pressure also loads the seventh piston in the same direction. When transfer valves connect the control ports of one or more pistons to the supply, these pistons extend, giving an output equal to the sum of their strokes. Each piston has twice the stroke of the one preceding it (from 0.015 to 0.96 in.) permitting the actuator to have 128 discrete output positions. There is no feedback system, but a displacement encoder supplies a 7-bit binary signal indicating the position of the heads.

All cylinders and pistons are lap fitted, eliminating seals in these areas and reducing leakage at the output shaft to virtually zero. Only one dynamic seal is used in the actuator assembly. All parts of the actuator are made of the same material and hence have the same temperature coefficient, allowing the assembly to operate over a wide temperature range with no adverse effect on accuracy.



Linear actuator has 128 discrete output positions.

Switching Circuit Backs Up Light Source

N. K. SHANKAR
Bausch & Lomb, Inc.

Control and measuring systems often include a photoelectric function generator with an incandescent light source, and lamp failure usually renders the system inoperative. This novel transistor circuit automatically switches over to a standby lamp when the main lamp fails. A third lamp monitors circuit operation and indicates: 1) normal working of the main source lamp, 2) switchover to the standby lamp, and 3) condition of the standby lamp.

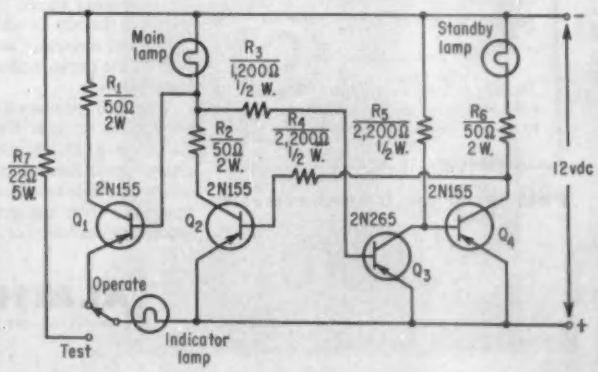
The circuit, figure, resembles a flip-flop with Q_3 on one side and Q_5 and Q_4 in cascade on the other. Q_1 and the indicator lamp are connected across the main lamp switching circuit. Only one supply voltage is required.

Normally, Q_3 is biased on by the negative voltage applied to its base through the standby lamp, R_4, and R_5. Its base current is too small to light the standby lamp, but current flowing through R_5 and the low collector-emitter impedance of Q_3 does light the main lamp. At the same time the voltage at the junction of the main lamp and R_5 is applied to the bases of Q_1 and Q_5 to switch on these transistors. The rather small emitter current of Q_1 lights the indicator lamp dimly. Q_5 clamps the base of Q_4 to nearly the emitter voltage, so Q_4 remains off and the standby lamp does not light.

Main lamp burnout removes negative supply voltage from the bases of Q_1 and Q_5 and from the collector of Q_5. These three transistors stop conducting, the indicator lamp goes out, and Q_3 appears as an open circuit across the emitter and base of Q_4. The Q_4 base is now biased negative through R_6, Q_4 conducts, and the standby lamp comes on.

Now suppose that the main lamp is operating and the filament in the standby lamp opens up. This removes base bias from Q_3, Q_3 ceases to conduct, and the voltage at the R_5-R_6 junction (and on the base of Q_1) goes more negative. Q_1 then conducts more heavily, drawing enough base current to keep the main lamp lit and making the indicator lamp in its emitter circuit glow brightly as a warning.

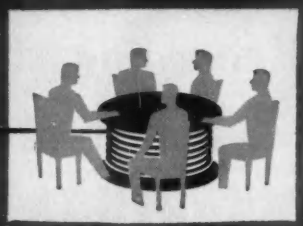
The switch is for checking the indicator lamp itself. If this lamp is out but lights when the switch is thrown to "test", the circuit has switched over; if not, it has burned out.



Circuit monitors lamp condition, switches in standby when required. Main and standby lamps are 6.3 volt, 0.5 amp.; indicator is 2.3 volt, 0.15 amp.

DU PONT

WIRE AND CABLE ROUND TABLE



You have asked . . .

Q. Your natural-color polyethylene for high-voltage insulation, ALATHON 3B, NC10, has been around for several years now. Have you introduced a better resin?

A. No . . . nobody (including us) has been able to match the resistance of ALATHON 3B, NC10, to combined corona and mechanical stretching (bending) under a variety of conditions. The search for a successor may be academic since we have never had a failure in any of our 15KV cables insulated with the 3B resin. Nevertheless, eternally optimistic about maintaining a lead, we have lots of new compounds under test. If one looks better, we'll be in touch with you.

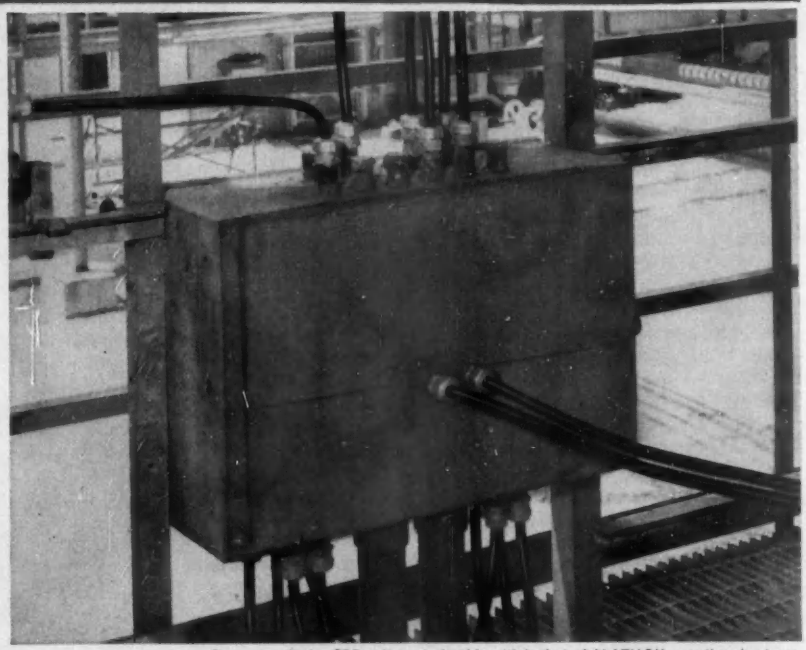
Q. If ALATHON 3B is so good, tell me how I can be sure of getting its outstanding properties without naming brands?

A. Rely as you ordinarily do, on the judgment of responsible cable manufacturers. There is no simple way yet, outside of our published electro-mechanical stress-crack test, or some equivalent way (not all of which are reproducible) of separating resins of superior electrical life from others of identical melt index and density. Nevertheless, for the present, it will narrow the field somewhat to specify a melt index of 0.2 to 0.4 and density in the general range of 0.92.

Du Pont does not manufacture wire and cable, but supplies thermoplastic resins to the wire and cable industry.

POLYCHEMICALS DEPARTMENT

DU PONT
REG. U.S. PAT. OFF.



Seven-conductor 600-volt control cable with jacket of ALATHON over the aluminum sheath offers necessary corrosion protection for chemical plant hook-up.

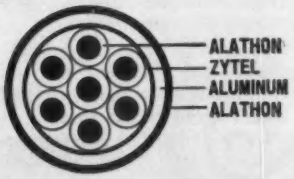
General Cable uses ALATHON® and ZYTEL® for unique control cable construction

The problem of acute corrosion attack on metal conduits has been licked at a Texas chemical processing plant. A unique control cable construction, utilizing a 0.032" jacket of Du Pont ALATHON 4, BK-30, polyethylene resin over the aluminum sheath, has solved the problem. The cable is manufactured by General Cable Corp. of New York.

The jacket of ALATHON completely protects the aluminum sheath from the corrosive elements in the air. In addition, it also provides additional electrical and mechanical protection to the cable, and allows quick and neat installation.

The 0.020" primary insulation over the seven conductors in this 600-volt cable is also ALATHON 4, BK-30. This black, weather-resistant type of insulation was used to protect the cable at outside terminations in the open plant structure. Over the primary, a thin 0.004" secondary insulation of ZYTEL 37X nylon resin is used for mechanical protection at termination points. The skin of ZYTEL, which is also weather-resistant, completely protects the cable from rough handling and the abrasion found in crowded junction boxes.

Find out how insulation and jacketing of the Du Pont plastics may give you installation savings. Consult your wire and cable manufacturer, or write: the Du Pont Company, Dept. CE-8, Room 2507A, Nemours Bldg., Wilmington 98, Del. In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Quebec.



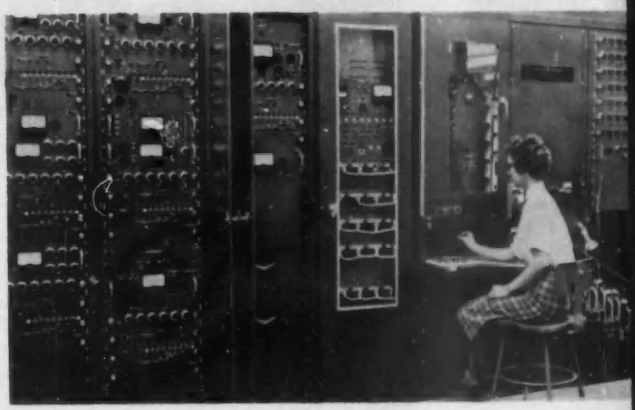
ALATHON® POLYETHYLENE RESINS | **RULAN®** FLAME-RETARDANT PLASTICS | **ZYTEL®** NYLON RESINS

NEW PRODUCTS

10 AUTOMATIC SYSTEMS test components, classify data, and compute trends.

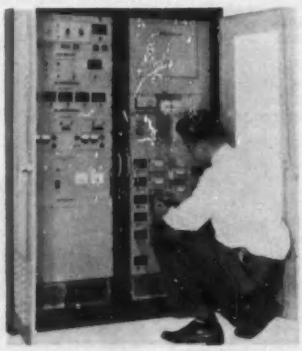
Representing the first complete line of automatic testing systems available for industry, ten new quality information and test systems (QIT) have been announced. These ten, and others still to be introduced, will feature automatic programming of test sequences and limits, integrated construction of testing and data handling functional modules, cellular presentation of test results to be analyzed by a trend computer, and profitable balance of economics with process dynamics. Other QIT systems not shown here are a basic appraisal system for incoming components (309), a spark and mark cable tester (310), a dynamic circuit analyzer (311), and a relay in-line tester (312).—Specialty Control Dept., General Electric Co., Waynesboro, Va.

Circle indicated number (309-318) on reply card



Automatic transistor classifier moves production by salable model numbers into bins.—$35,000-60,000. (316)

Programmed automatic circuit tester scans up to 3,600 points at 540 per sec.—About $20,000. (313)



An automatic diode grader senses polarity of selenium diodes, performs electrical test, and either accepts or rejects them, sorting them into one of 11 bins. Rate of grading is 30 per min.—$15,000-27,000. (317)

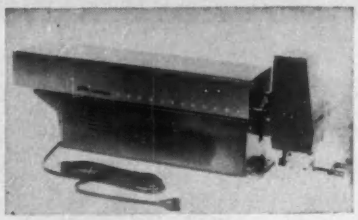
The Autotran transformer tester performs six operations following punched tape program: induced voltage, hi-pot, exciting current, voltage ratio and polarity, core loss. Results appear in two places. —$20,000-30,000. (314)

Multicycle reliability tester checks variety of units in 1/100 manual time from tape program. — About $21,000. (318)

Relay tester makes 203 measurements and classifies 8 parameters in 30 sec.—About $24,000. (315)

NEW PRODUCTS

SYSTEMS



LOW COST ROBOT

Built to sell at $2,500, this industrial robot materials handler is said to be the first such device available as a stock item. The TransfeRobot 200 can move a standard load of 1 lb (maximum of 5 lb) 2 in. vertically and shift it 10 in. along the arm's axis. The arm also rotates and opens and closes its jaws. Speed of operation is 30-60 complete cycles per min. Programming is by setting cams and stops for motion and by setting switches for relationship with other machines or jaw action. Reprogramming for new work should take no longer than 30 min. The robot arm can also be rented.—U. S. Industries, Inc., Robodyne Div., Silver Spring, Md.

Circle No. 319 on reply card

DESK COMPUTER

Newest addition to this manufacturer's line of data processing equipment is the Recomp III, a small scientific computer. The machine has a 4,096-word magnetic disc memory, each word having 40 bits. The computer can handle 8,000 instructions. Standard input and output is by typewriter or tape punch at 10 characters per sec. Main memory access time is 9.3 millisec, which can be reduced to 1.75 millisec by using two high speed loops. For fixed point computation, operation time is 0.54 millisec for add-subtract functions. Computer including desk measures 30 x 30 x 60 in. Standard 115-vac supply is required. Sale price: $65,000; lease $1,495 per month.—Autonetics Div. of North American Aviation, Inc., Downey, Calif.

Circle No. 320 on reply card

HYDROPNEUMATIC NC

Said to be the first tape reading numerical control based on pneumatic and hydraulic principles, the Hydra-Point system is priced at about 10 percent less than most comparable electronic control installations. The system had not previously been available separate from a machine tool. System design is said to result in easy maintenance, greater speed of operation, and low cost. Tape positioning speeds are 350-700 in. per min, and positioning accuracy is to within ±0.0005 in.—Industrial Div., Moog Servocontrols, Inc., E. Aurora, N. Y.

Circle No. 321 on reply card

DATA HANDLING & DISPLAY

TWO-WAY PLOTTER

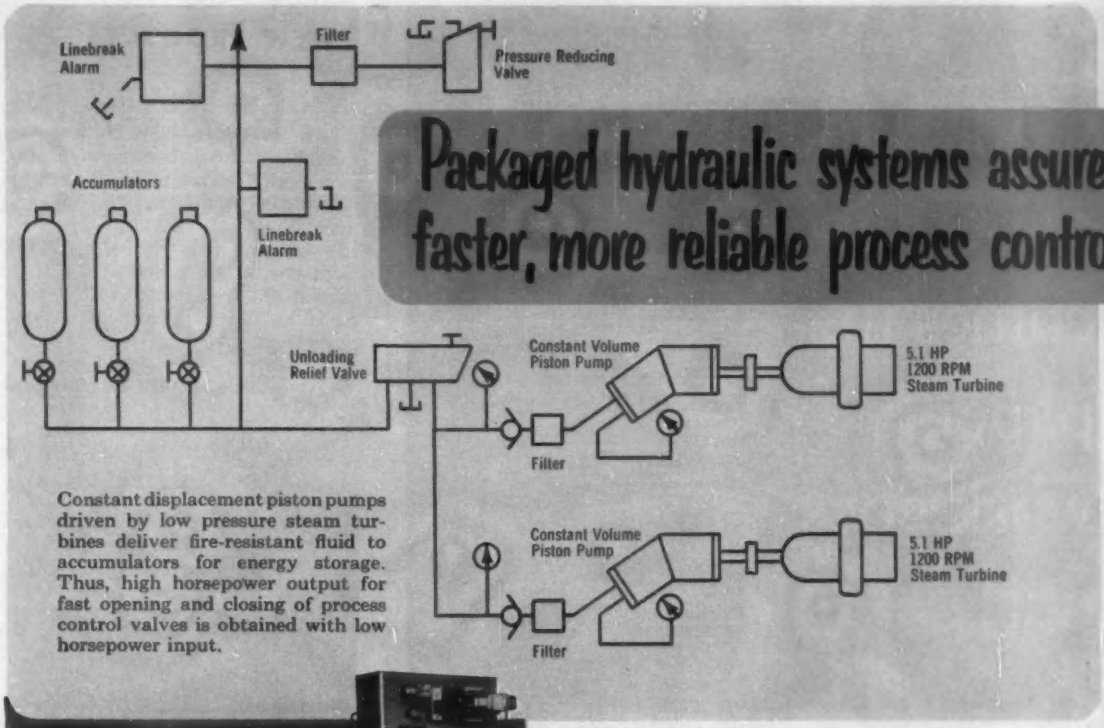
Two simultaneous plots of any four independent voltages against time are recorded on this Model 1587 plotting board. Plotting surface may be tilted to either horizontal or vertical position. Tilting is accomplished electrically and can be done during plotting Recording pens cover entire 30 x 30 in. surface with acceleration of the pen at 1,350 in. per sec^2. Pens are mounted on movable arms that accelerate at 450 in. per sec^2. Arm collision is eliminated by automatic circuits. Accuracy of the plot is to within 0.05 percent. Price: $16,100.—Milgo Electronics Corp., Miami, Fla.

Circle No. 322 on reply card

DATA COLLECTORS

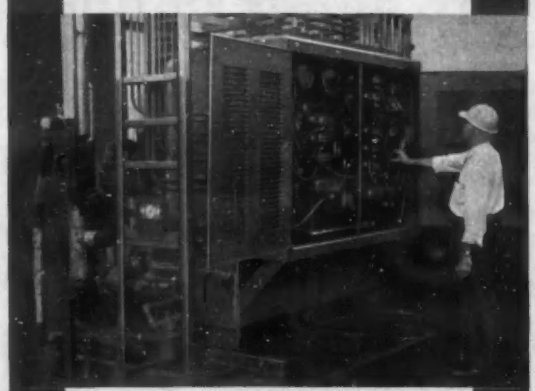
Two new systems for collecting and transmitting data from remote locations have been announced. The 3100 Shoptrol system is a factory monitoring and data collector set up for timely reaction to factory conditions. It consists of a control center and status monitors installed in groups of 20 at the control center for receiving information from work stations, paging collectors and operating control stations. The 3101 data collection system is de-

Packaged hydraulic systems assure faster, more reliable process control



Constant displacement piston pumps driven by low pressure steam turbines deliver fire-resistant fluid to accumulators for energy storage. Thus, high horsepower output for fast opening and closing of process control valves is obtained with low horsepower input.

Control console and power unit form electro-hydraulic system for controlling automatic heat treatment cycle. Physical layout provides optimum circuit efficiency, ease of servicing, and good appearance.



This power package includes all hydraulic pumps and valves for complete control of automatic cyclic operation of process in a butadiene plant.

Fast and precisely controlled motions, having the high reliability demanded by modern processing, are inherent characteristics of hydraulics. In addition, these advantages are obtained at low cost, for you can cover your full range of operations—from valve control to power transmission—with standard Vickers components. Your engineers enjoy unlimited design flexibility through a choice of electric, electronic, pneumatic and manual signals to control the hydraulic pumps, motors, cylinders, and variable speed drives.

Vickers complete packaged systems are ready to go into service upon arrival in your plant, since they are thoroughly pretested before shipment. They are properly designed and built to give maximum service life with little downtime, thus helping to keep your plant on stream.

Get more information on the job being done by Vickers packaged hydraulic systems in chemical, petrochemical, petroleum refining, and other processing industries by writing today for Bulletin I5802, "Packaged Hydraulic Systems for Process Control."

VICKERS INCORPORATED
DIVISION SPERRY RAND CORPORATION
ADMINISTRATIVE and ENGINEERING CENTER
Department 1606 • Detroit 32, Michigan

9138

CIRCLE 115 ON READER SERVICE CARD 115

NEW PRODUCTS

signed for transmission of fixed and variable data from various remote areas to a central accumulator. It converts information from punched cards and manual dials to electrical signals for transmission to a central collector. Both systems are priced in the range of $20,000 to $40,000 with leasing available.—General Electric Co., Computer Dept., Phoenix, Ariz.

Circle No. 323 on reply card

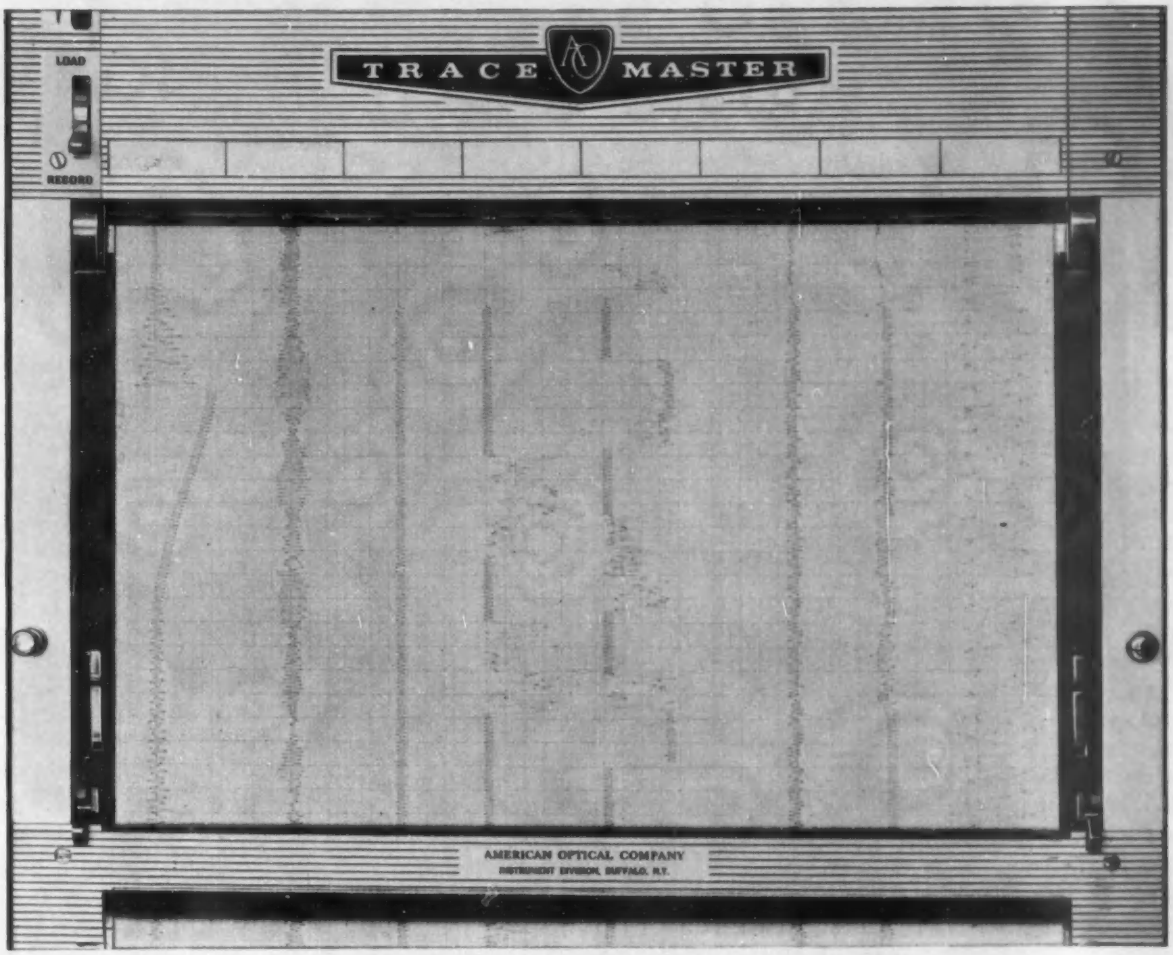
PHOTOELECTRIC ENCODER

Said to be the first photoelectric binary encoding keyboard, the K-144 alphanumeric unit features an exclusive technique which permits generation of any 5, 6, 7, or 8-bit binary code. Encoding matrices, contacts, and switches used in other keyboards are eliminated. When key is depressed, associated binary code shutter modulates light channels. Binary coded light data result in resistive changes in a bank of photoconductors corresponding to the binary code. Optional amplifier can convert the photoconductor signals to signals compatible with computer logic. With a 44-key keyboard, the device sells for $550.—Invac Corp., Natick, Mass.

Circle No. 324 on reply card

FAST RANDOM FILE

A new "cylinder" concept of file organization is used in this high speed random access disc storage unit. Contrasted with the one-head arrangement of the manufacturer's 350 (used in the RAMAC 305 system) and 1405 (used with the 1401 and 1410 systems), the new 1301 file uses two stacks of 20 discs with a read/write head for each of the 40 surfaces in each stack. Data are read in or out in a vertical column, so there is no vertical movement of the heads, cutting access time. Two-stack units have 50-56 million character capacity, depending upon which of the manufacturer's computers they



AO Trace-master provides twice the definition of any other direct writing technique

The unique direct-carbon-transfer writing method produces a trace from 2 to 3 times finer than any other direct-writing technique. This allows twice as many lines per millimeter . . . twice the definition! Resolution is unsurpassed . . . each line is uniform in width and contrast, revealing the most minute variations in the phenomena measured with utmost fidelity. This writing technique combined with the advanced pen-motor design produces a wider frequency response at larger amplitudes. Continuous recording of data can be displayed simultaneously on 8 channels . . . up to 8 independent event markers can be added. Ten chart speeds — 0.1 to 500 mm/sec — provide a 5000:1 chart speed ratio.

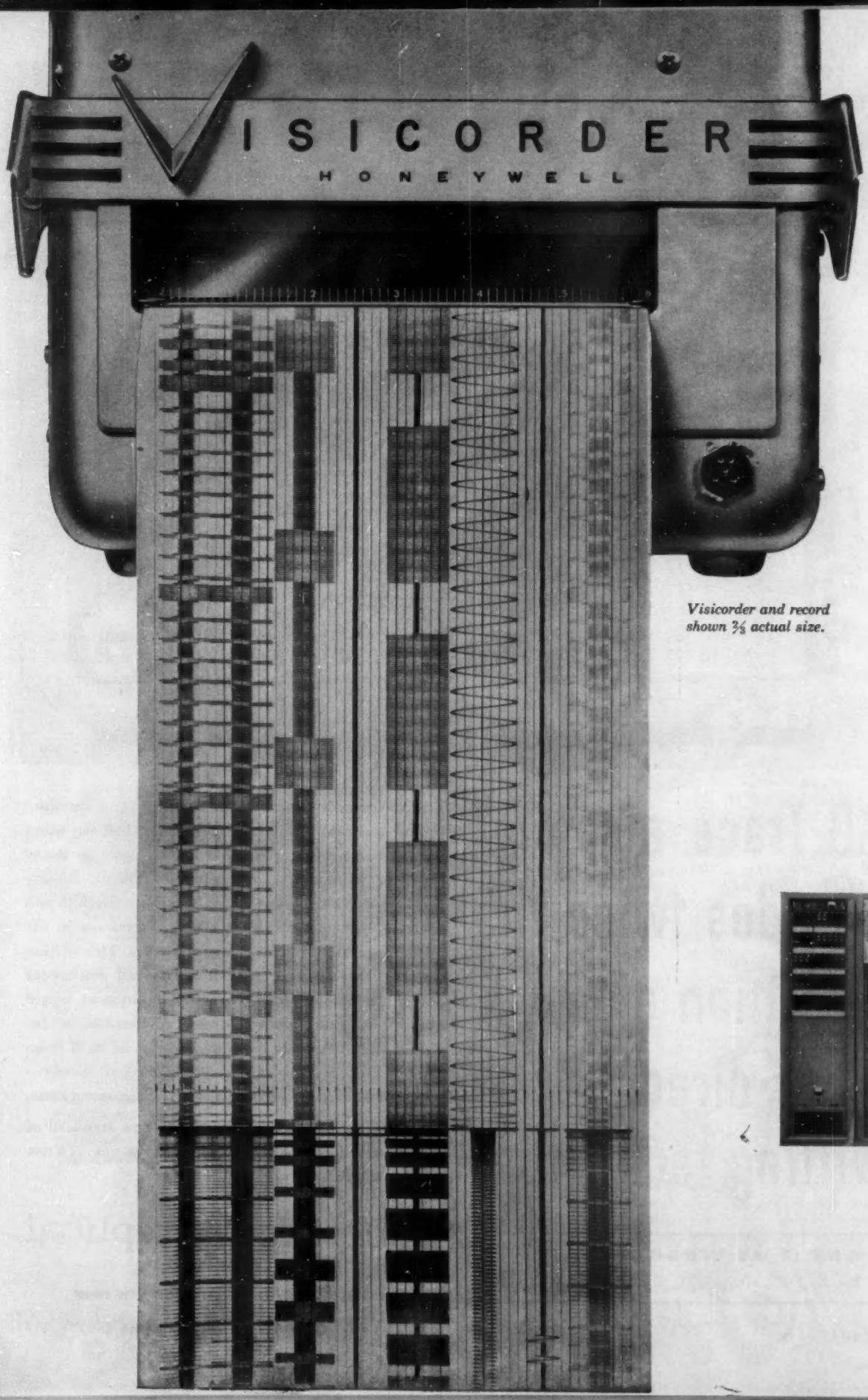
The AO Tracemaster has become the new standard of performance for these and many other reasons . . . write now for the full story!

SEE IT AT WESCON...
Booths 3707, 3709, 3711, 3713

American Optical
COMPANY

INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

CIRCLE 117 ON READER SERVICE CARD 117



Visicorder and record shown 3/5 actual size.

"MASTER CLOCK"

for the missile range uses 15 Honeywell Visicorder oscillographs

The Timing Operations Center designed and built by Epsco-West for the Navy's Pacific Missile Range is now in use at Point Mugu, California. It makes use of 15 Honeywell Visicorders to read out (as shown on the unretouched record at left) the modulated timing codes distributed as balanced outputs to the Center's "customers."

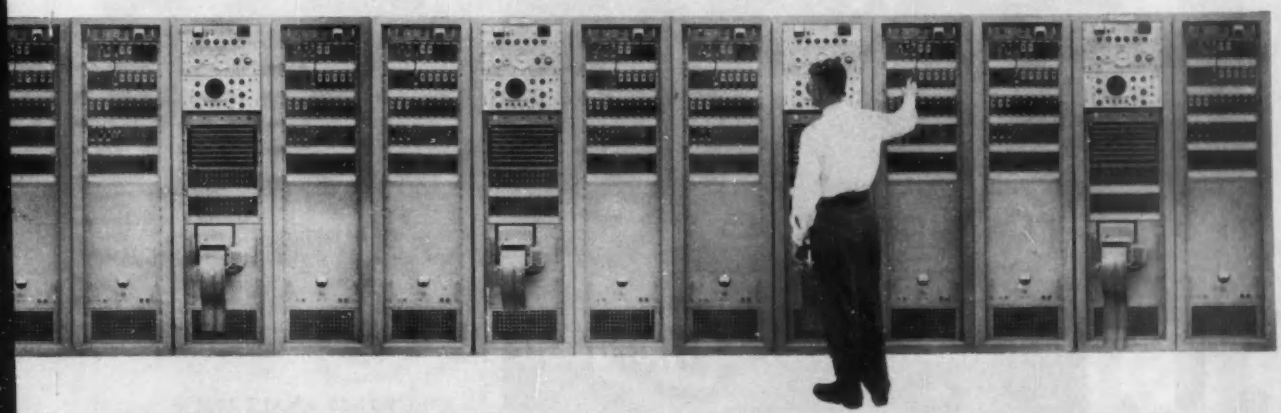
These customers are the test and development crews on weapons systems, satellites, space vehicles or any other users of the facility who depend upon extremely accurate timing signals for many purposes including satisfactory correlation of telemetry data. The TOC generates as many as eleven separate timing signals, any one of which may be delivered to any of 36 users at one time.

Entirely solid-state, the Epsco-West TOC consists of a precision frequency standard, the 100-kc/sec output of which is accepted by the timing signal generator and divided down to one pulse per sec by digital divider units. The 1-pps signal is accumulated in binary-coded decimal format by a counter-type register permuted to read out in hours, minutes, and seconds. Recycling occurs at 23:59:59. Controls include advance or retard in 10-microsecond increments.

The 906B Visicorder also performs a supplementary function as a monitor on the timing and test-patch panel, and as permanent "record-keeper" for the built-in indicators and test oscilloscopes. Visicorders were selected for their jobs with the TOC because of their versatility, reliability, low cost, and compact size (10″ x 10″ x 15½″; weight, 37 lbs.).

Pioneer and acknowledged standard in the field of high frequency direct-recording oscillography, the Visicorder is available in several models, from 6 to 36 channels, DC to 5000 cps response, up to 20,000″/sec writing speed. Honeywell engineering is at your service through 120 field offices for help in applying one Visicorder or a full system to your data acquisition program; or a quantity of Visicorders for OEM application in your products.

Call your local Honeywell office now or write today for Catalogs HC906B, 1012, 1108, and 1406 to Minneapolis-Honeywell, Heiland Division, 5200 E. Evans Ave., Denver 22, Colorado. Our telephone is SKyline 6-3681, Area Code 303.



Viscorders are conveniently installed in control consoles of three-rack TOC modules. Records are immediately legible without chemicals or developing.

Honeywell

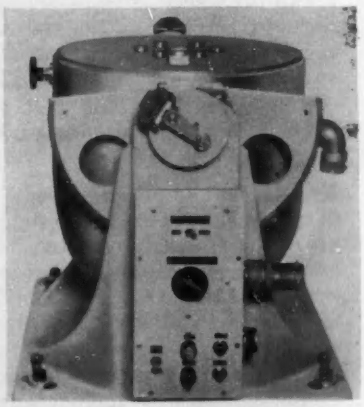
Industrial Products Group

CIRCLE 119 ON READER SERVICE CARD

are used with; access time can vary from 17 millisec to 180 millisec max. (A double density 350 has 10 million capacity, average access time of 600 millisec; double density 1405's capacity is 20 million, with same access time.) Two-stack 1301 sells for $185,000 and rents at $3,500 per month. First deliveries will be in about one year.—International Business Machines Corp., Data Processing Div., White Plains, N. Y.

Circle No. 325 on reply card

RESEARCH, TEST & DEVELOPMENT



TUMBLE RATE TESTER

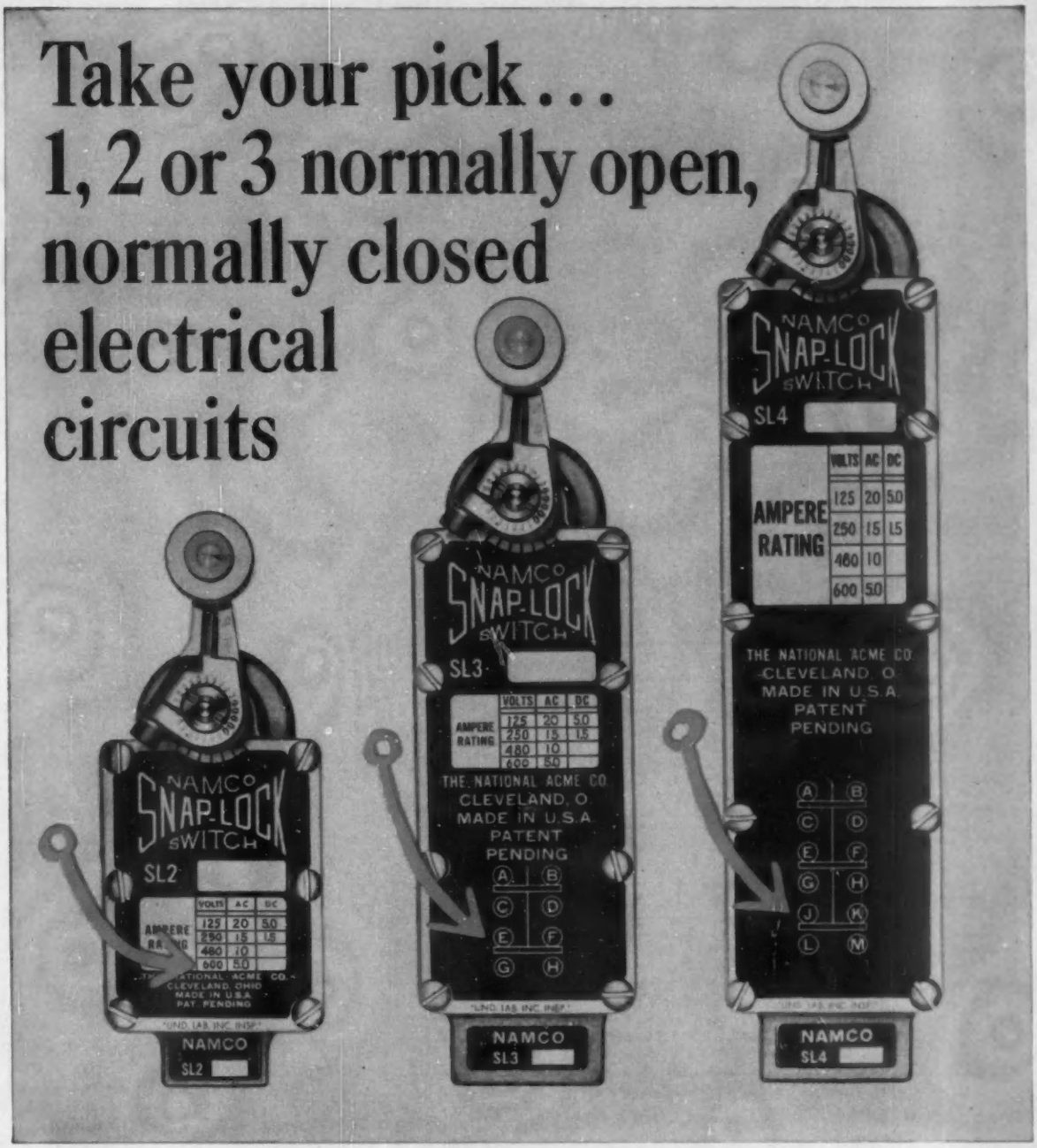
This highly precise unit is designed to test gyros and other devices requiring precise orientation or rotation. The CO5 6452 009 tumble rate test stand features a rotary table locking arrangement that permits selection of 0, 90, 180, and 270-deg static angular positions. Precise tapered roller bearings are used for rugged, low friction, accurate mounting. Rotation rates are 150 and 300 deg per hr. Table rate stability is within 0.2 percent. Axis wobble is 10 sec of arc max.—Kearfott Div., General Precision, Inc., Little Falls, N. J.

Circle No. 326 on reply card

SPECTRUM ANALYZER

Analysis, display, and recording of complex waveforms can be carried out simultaneously on two new Rayspan spectrum analyzers. The MRFR 30-9 analyzes a signal by applying it

Take your pick... 1, 2 or 3 normally open, normally closed electrical circuits



What does your limit switching application call for . . . one, two or three normally open, normally closed electrical circuits? Whatever it is, one of these National Acme SL "Machine Life" Limit Switches . . . the SL2, the SL3 or the SL4 . . . will meet your precise requirement. And, every SL offers . . . a variety of cam arrangements for extreme operating flexibility . . . ample overtravel (67°) and by-pass (90°) . . . light operating pressure (10½ lbs. at 1½" radius). Also available . . . the SLS 2, 3 or 4 featuring "hi-shock" sliding contacts; particularly suitable for drop forge, punch press and other heavy equipment application. Call, write or wire for complete information.

National Acme

THE NATIONAL ACME COMPANY
165 E. 131st STREET
CLEVELAND 8, OHIO

Sales Offices: Newark 2, N. J., Chicago 6, Ill., Detroit 27, Mich.

CIRCLE 121 ON READER SERVICE CARD 121

NEW PRODUCTS

simultaneously and continuously to a bank of 100 3-cps filters. The filters allow an analysis of any 300-cps band from 5 cps to 10 kcps. Filter outputs are sampled in sequence by a fast capacitive commutator, and the detected signal is amplified and displayed on an oscilloscope. The MRFR 30-11 uses 420 3-cps filters for a 1,260-cps band. Prices are $5,500 and $15,975, respectively.—Raytheon Co., Industrial Components Div., Newton, Mass.

Circle No. 327 on reply card

SENSITIVE 'SCOPE

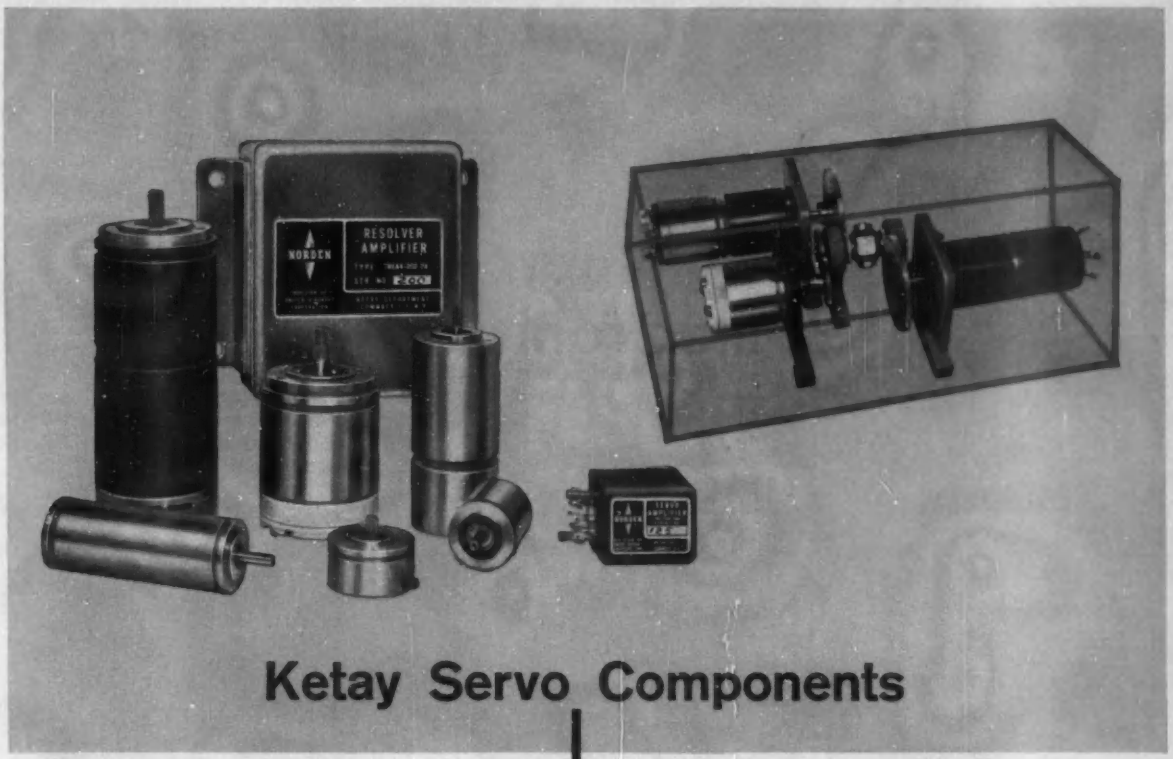
Said to be the most sensitive commercially available oscilloscope, the Type 403-B has a sensitivity of 50 microvolts per cm and low noise level to permit resolution of signals as low as 10 microvolts. The unit is useful beyond 3 Mcps and features high amplification with low noise input. Outputs of strain gages, pressure pickups, accelerometers, and other low level transducers can be displayed without amplification. Calibrated wave sweeps are available from 1 microsec per cm to 5 sec per cm.—Industrial Electronics Div., Allen B. Du Mont Laboratories, Divs. of Fairchild Camera and Instrument Corp.

Circle No. 328 on reply card

PRIMARY ELEMENTS & TRANSDUCERS

POT PRESSURE CELL

Designed for use in severe environments, this new improved poten-



Ketay Servo Components

available separately... | or in modular packages

Ketay servo components are recognized throughout industry and military agencies for outstanding accuracy and reliability. The advanced designs and quality control techniques provide precision to satisfy the most exacting requirements of today's servo systems.

Now this same high reliability is available to your servo systems with Ketay modular packages. These packages are produced with the identical quality control procedures as are the individual components . . . and provide your servo systems with the maximum accuracy of the individual components.

* * *

Here are a representative group of Ketay components available separately or packaged in combination.

SYNCHROS. Control and torque transformers; transmitters and receivers; torque and control differential transmitters to MIL-S-20708A. Sizes 05 to 31.

SERVO MOTORS. Featuring high ratio of stall torque to power input at maximum rpm. A wide variety in frame sizes from 05 to 23. Exceed environmental requirements of MIL-E-5272A.

AMPLIFIERS. Complete range of servo amplifiers, transistorized and magnetic. Outputs from 1.5 to 9 watts, designed to operate in ambients from −55° to +125°C. Also dual channel resolver amplifiers.

POTENTIOMETERS. A wide choice of types including single-turn and multi-turn, with linear and non-linear windings, ganged potentiometers as well as sector and pendulum pots. High temperature (to 300°C) and nuclear resistant models.

RESOLVERS. Size 08 to 23 resolvers available offering functional accuracies to .03%, stability over a range of −55°C to +125°C, high input impedance. Vernier resolvers available with null spacing accuracy of 10 seconds.

FLOATED RATE GYROS. Variety of gyro spin motor and pick-off characteristics may be combined to fulfill desired specifications.

MOTOR TACHOMETERS. Integrating and damping types. Size 15 integrating model requires no warm-up time, meets environmental requirements of MIL-S-17806. Size range from 08 to 18.

NORDEN

Ketay also manufactures a complete line of precision encoders, servo motors, resolvers, motor tachometers, gyros, and amplifiers, in a wide range of sizes and specifications to meet your specific requirements. Components are available separately or in modular packages.

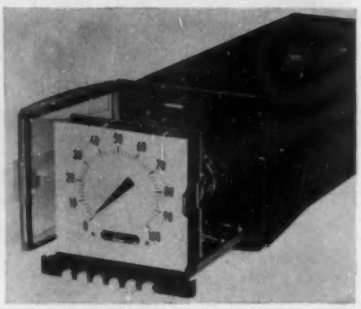
division of UNITED AIRCRAFT CORPORATION

COMMACK, LONG ISLAND, NEW YORK

NEW PRODUCTS

tiometer transducer functions with less than ±1 percent instantaneous ac error during vibration of 50 g to 2,000 cps. Sensing element is a precision Ni-Span-C Bourdon tube. Multiplication of movement does not require pivots or linkages. Unit is linear within 1 percent, and hysteresis is as low as 0.5 percent for ranges to 1,000 psi. Seven models are available in ranges of 0-2,000 psi to 0-5000 psi, absolute or gage. Units weigh 4½ oz and measure 1¾ in. in diam by ⅞ in. Price: $185 to $225.—Control Components Div., International Resistance Co., Philadelphia, Pa.

Circle No. 329 on reply card



ACCURATE LEVEL INDICATOR

High accuracy, flexibility, and low cost are features of this 959 series capacitance operated level indicator. Device accepts inputs from a variety of probes and indicates and controls them on the receiver shown above. The receiver uses solid state circuits of plug-in design and is accurate to within less than 1 percent. Circuitry involves a self-balance bridge with a servo readout to elminate drift. Unit measures 6 x 6 x 16 in. deep and operates on 115 volts, 60 cps. Indicator price: $550; probes: about $50.—Magnetic Instruments Co., Inc., Thornwood, N. Y.

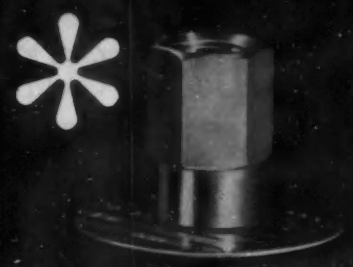
Circle No. 330 on reply card

ACCURATE PRESSURE SENSOR

This new high range absolute pressure transducer, the Model 737, is of miniature size, but meets all applicable government specifications. Static error band is ±1.2 percent. Multiplying linkages are eliminated by use of direct acting electrical pickoff.

Characteristics:

Ranges: 0-4,000 to 0-10,000 psi.
Resistances: 1-10 kilohms ±5 percent
Resolution: to as low as 0.2 percent
Dimensions: 1 in. in diam by 1.48 in.
Weight: approximately 4 oz.



3 TIMES FASTER CYLINDER PISTON RETURN

THAN WITH COMPARABLE SOLENOID VALVES

ASCO MIDGET 3-WAY—ACTUAL SIZE

OVERSIZE EXHAUST

NORMALLY OPEN NORMALLY CLOSED, OR UNIVERSAL OPERATION

MOUNTS IN ANY POSITION

ONLY 2 MOVING PARTS

The ASCO Bulletin 8317 Solenoid Valve provides the fastest cylinder or diaphragm return of any valve its size. For example, at 100 psi a 12" return stroke in a 3" cylinder takes 2½ seconds with the 8317 . . . 7 seconds with a comparable valve. This remarkable 3-way solenoid valve can be substituted for larger, more expensive units normally required to obtain fast return.

In other 3-way valves, the fast rate of flow under pressure usually provides quick operation of the cylinder or diaphragm, but the dissipation of pressure on exhaust results in a slower return stroke. The large exhaust orifice on the Bulletin 8317 (over 7 times greater than the inlet area) quickly vents the pressure, permitting the piston or diaphragm to return rapidly.

The ASCO Bulletin 8317 has only 2 moving parts . . . mounts in any position . . . is available in normally open, normally closed and universal construction . . . with general-purpose, explosion-proof or watertight solenoid enclosures in ¼" pipe size . . . for pressures up to 160 psi . . . for water up to 100° F. or air, gases and light hydraulic oil up to 180° F. It is immediately available from stock, as are other ASCO solenoid valves.

WRITE FOR BULLETIN 8317, providing complete descriptive information on this new, "midget," quick-exhaust 3-way.

ASCO Valves ASCO

DEPENDABLE CONTROL BY Automatic Switch Co. HANOVER RD., FLORHAM PARK, N. J. • FRONTIER 7-1000 • *AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL*

CIRCLE 125 ON READER SERVICE CARD

ONE OF THESE NEW GE MANAGEMENT CONTROL

New GENERAL ELECTRIC SHOPTROL *System monitors individual work stations...displays production status at a control center for timely reactions to factory conditions.*

The GE SHOPTROL SYSTEM is a factory monitoring and data collection system that monitors work stations and records production data at a central point. Each work station's status is visually displayed on a Status Monitor. Status Monitors present a panoramic view of up-to-the-minute factory conditions for visual display at the Production Control Center. Work stations have an operator control station, or an alarm station terminating at the Control Center. Depending on complexity of communication needed and data to be transmitted, a paging selector may be added to each work station.

The Shoptrol System records, in hundredths of hours, time elapsed for operations, set-up and tear down, unavoidable delays, machine running, and machine off conditions. The Shoptrol System can record time elapsed, or count pieces or operations.

The Shoptrol System provides direct signal communications from work stations to the Production Control Center. The operator control station and paging selector have phone jacks to provide entry into the telephone intercom. Units are ruggedly built for dependable life in factory conditions.

Totals recorded from the Status Monitors at the end of shift produce information for production control analysis and management decision making. The data is readily convertible to punched cards or paper tape for input to a data processing system. For more information, write for brochure CPB-152, General Electric Company, Computer Department, Section 90G8, Phoenix, Arizona, or your District Office listed below.

THE GE SHOPTROL SYSTEM CONTRIBUTES TO GREATER PRODUCTION EFFICIENCY BY:

...providing constant communication between production control center, foreman, and work station operators.

...collecting and displaying current production data for each work station.

...increasing accuracy of production records.

...providing immediate production status for management at all times.

Atlanta: 270 Peachtree St. N.W., 522-1611 • **Boston:** 140 Federal St., HU 2-1800, Ext. 311 • **Chicago:** 120 S. La Salle St., 782-5061 • **Cleveland:** 215 Euclid Ave., SU 1-6822 • **Dallas:** 3200 Maple Ave., RI 8-0589 • **Detroit:** 680 Antoinette St., TR 2-2600 • **Houston:** 4219 Richmond Ave., MO 7-3301 • **Kansas City, Mo.:** 106 W. 14th St., GR 1-2919 • **Los Angeles:** 1010 S. Flower St., DU 1-3641 • **Louisville:** Bldg. 6, Appliance Pk., GL 4-7511 • **Minneapolis:** Plymouth Bldg., 6th & Hennepin, FE 2-7569 • **New York:** 122 E. 42nd St., PL 1-1311, Ext. 3205 • **Philadelphia:** 3 Penn Center Plaza, LO 8-1800 • **Phoenix:** Guaranty Bank Bldg., 3550 N. Central Ave., AM 4-3741-2 • **Pittsburgh:** 1634 Oliver Bldg., Melion Sq., AT 1-6400, Ext. 566 • **San Francisco:** The Russ Bldg., 235 Montgomery St., DO 2-3740 • **Schenectady:** Bldg. 2, 1 River Rd., FR 4-2211, Ext. 5-4405 • **Seattle:** Dexter Horton Bldg., 710 Second Ave., MA 4-8300 • **St. Louis:** Paul Brown Bldg., 818 Olive St., GE 6-4343 • **Syracuse:** 1010 James St., GR 6-4411, Ext. 6141 or 6142 • **Washington, D.C. Area:** 7401 Wisconsin Ave., Suite 514, Bethesda, Md., OL 2-8100

SYSTEMS WILL SAVE YOU MONEY THIS YEAR

New GE 3101 DATA ACCUMULATION and COMMUNICATION *System provides immediate plant/office data communication...as a management tool to increase production and reduce costs.*

The GE 3101 is General Electric's answer to the need for an economical and effective means of collecting operational data. Key areas such as purchasing, receiving, quality control, shop operations, warehouse, shipping, etc., send current data to a central point for collection and display. Each of the key areas has a Collector that sends data to the Accumulator, where it is punched into paper tape for a permanent record. Data originating at the Collector is from punched cards and/or 19 variable dial settings. Collectors may be up to 10,000 feet from the Accumulator.

The punched paper tape can produce a typewritten copy immediately for visual display of current conditions; can be converted to punched cards; or can be used for direct input to a computer system. Investigate this new, lower cost development by General Electric.

Installation of the GE 3101 information gathering system can result in greater operational profits due to: accuracy and timeliness of data, economy of operation, and quicker access to the facts for well informed decisions by management.

For more information, write General Electric Company, Computer Department, Section 90G8, Phoenix, Arizona, or contact your nearest General Electric Computer Department District Office listed below.

In Canada: Canadian General Electric Co., Ltd., Electronic Equipment and Tube Dept., 830 Lansdowne Ave., Toronto, Ontario, Canada. **Outside U.S.A. and Canada:** Producer Goods Export Department, International General Electric Company Division, 150 East 42nd Street, New York City, N.Y., U.S.A.

INFORMATION PROCESSING AUTOMATED BY GENERAL ELECTRIC

Progress Is Our Most Important Product

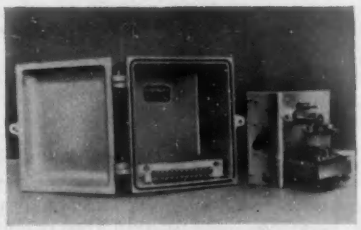
GENERAL ELECTRIC

CPA 90 (7-61)

CIRCLE 127 ON READER SERVICE CARD

NEW PRODUCTS

Price: about $400.—Bourns, Inc., Riverside, Calif.
Circle No. 331 on reply card



CAPACITANCE LEVEL PICKUP
The Contimitor is a capacitance operated monitor providing continuous indication of level on a meter or recorder. This extremely sensitive unit has excellent stability and freedom from drift as a result of using a crystal oscillator circuit. For the standard model a capacity change of 10 pf will give a reading of 1 ma full scale. For extreme sensitivity, unit can be made to give a 1-ma output for 0.03 pf. Applications include measuring paper and plastic thicknesses and counting. —Electronic Machine Co. Ltd., Thornton Heath, England.
Circle No. 332 on reply card

PLUS . . .
(333) A new rate gyro from **Humphrey, Inc.**, San Diego, Calif., is just 1.2 in. in diam and only 2.94 in. long. . . . (334) Incrosyn Model IMI 15-210, a new **incremental encoder** available from **Data Tech,** Cambridge, Mass., produces 1,024 pulses in a single turn with an accuracy of $\pm\frac{1}{2}$ bit. . . . (335) **Servo-Tek Products Co., Inc.,** Hawthorne, N. J., has placed on the market a new 45-volt, 1,000-rpm **tachometer** priced at $57.50.
Circle Nos. 333, 334, or 335 on reply card

CONTROLLERS, SWITCHES & RELAYS

ULTRASENSITIVE

Input power as low as 0.5 microwatt will actuate this sensitive static relay that will handle up to 750 watts, 60 cps. The ultRelay will operate in a temperature range of −40 to +60 deg F, and has a life expectancy of

"Ultra-high" can be any temperature beyond the range of your present measuring instruments. It might be 2000°F., 5000°F., or higher.

If you have temperature measurement problems that exceed the capabilities of generally available hardware or application experience, Honeywell's basic research, design, or production areas may have the answers you need.

Honeywell research and design specialists have been and still are extending the state of the art of high-temperature measurement. Write Dr. W. E. Kuether, MINNEAPOLIS-HONEYWELL, 151 E. Hunting Park Avenue, Philadelphia 24, Pa.

Honeywell

First in Control

HONEYWELL INTERNATIONAL Sales and Service offices in principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

CIRCLE 129 ON READER SERVICE CARD 129

NEW PRODUCTS

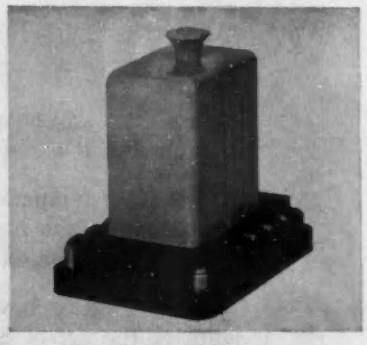
millions of cycles. Single pole models are available in either NO or NC configurations with single, double, or differential inputs. Relay measures 3 x 3½ x 3½ in. Approximate price is $85.—Industrionic Div., Airborne Accessories Corp., Los Angeles, Calif.

Circle No. 336 on reply card

VANE LIMIT SWITCH

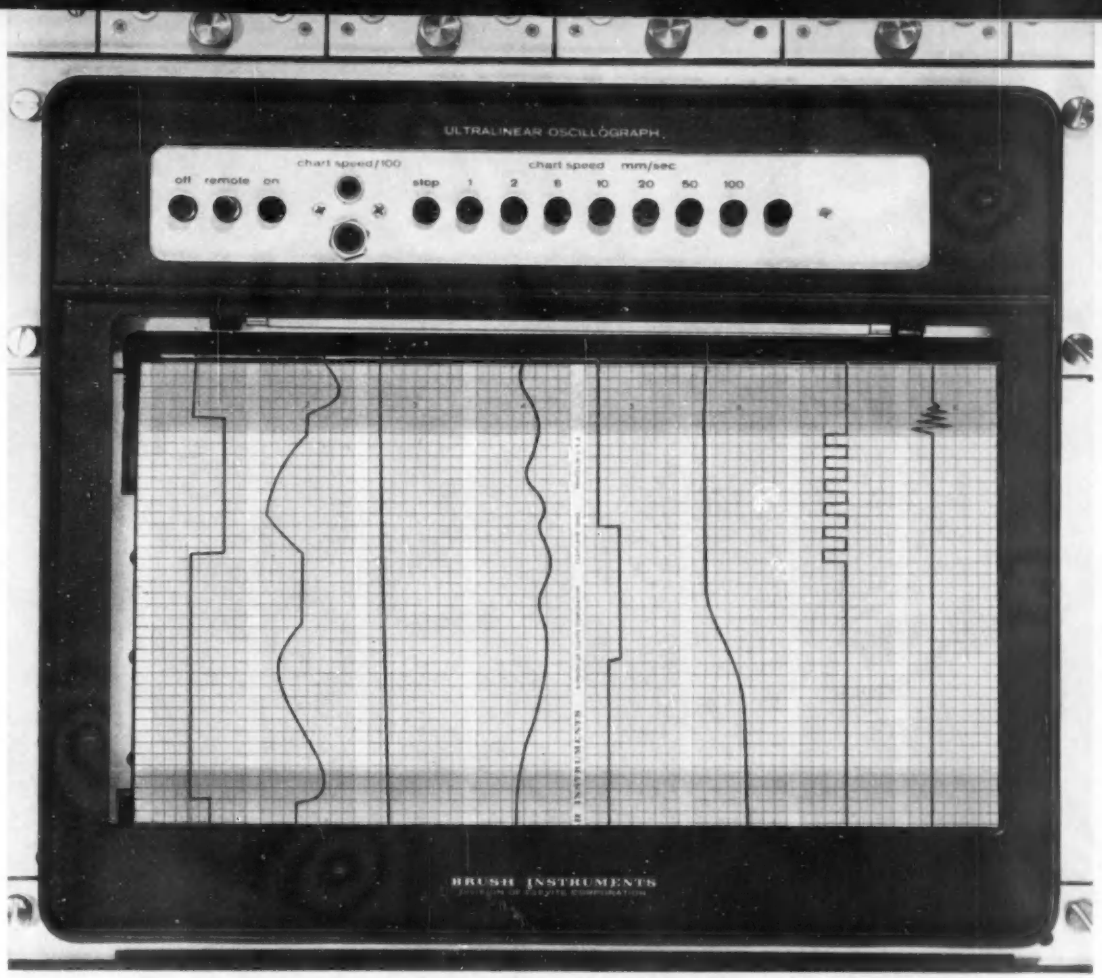
Actuation of this magnetic limit switch, made in West Germany and now available in the United States, is by means of an external vane passing through a slot in the sealed housing. There is no contact between static and moving machine components. Switch contacts are internally sealed in a tube filled with inert gas. Service life is said to be as high as 100 million cycles. Operation can be as rapid as 40 times per sec. Both NO and NC models are offered. Price: $35.—Sta-Fast, Inc., Anaheim, Calif.

Circle No. 337 on reply card



HEAVY DUTY UNIT

Designed for machine tool control and other heavy duty applications, this Class E relay has dust cover and screw terminals for heavy wire connections. Device is a small, rugged, telephone-type relay with mechanical life expectancy claimed to



in multi-channel recording systems there is nothing newer

It's no wonder this recorder has been chosen for today's most advanced telemetry and computer systems. Providing the highest precision and proven reliability, Brush's newest oscillograph instantaneously displays eight 40mm channels of analog data, plus two event markers. Sharp, easy-to-read traces on rectilinear coordinates. Accurate resolution of all signals and positive interpretation of amplitude is assured with 13 electrically controlled, precise chart speeds. All functions are operated by pushbutton and may be remotely controlled if desired. Unique auto-load system locks unit in any position for greatly simplified chart changing . . . without disturbing the styli. Take advantage of industry's most advanced techniques in this space-saving vertical panel oscillograph. Get *all* the facts. Call, write or wire.

brush INSTRUMENTS

DIVISION OF CLEVITE CORPORATION

3777H AND PERKINS CLEVELAND 14, OHIO

only Brush fills all requirements for multi-channel, multi-purpose recorders

If it's precise, instantaneous data acquisition in writing . . . Brush versatile recording systems provide the answer. Whether your requirements call for this "pull-out", horizontal model for convenient annotation and reading . . . or the newest in vertical panel recorders . . . you'll find all of the known refinements in the art of recording by direct writing. Rectilinear presentation gives clear, uniform, reproducible traces for precise readout. Up to 16 chart speeds are selected by pushbutton; jam-proof transmission provides quick response. Interchangeable "plug-in" signal conditioners permit four vital functions in addition to amplification—high input impedance, zero suppression, attenuation and calibration. Event markers, internal timers, remote control and chart take-up are some of the available accessories. Check these advanced recording systems for yourself and you'll see why no one is as qualified as Brush. Write for complete details.

brush INSTRUMENTS

DIVISION OF CLEVITE CORPORATION

37TH AND PERKINS CLEVELAND 14, OHIO

be 100-200 million operations. It is available with coils for 220 vdc operation or 110 or 220 vac operation. Prices range from $4 to $12.—Automatic Electric Co., Sub. of General Telephone & Electronics Corp., Northlake, Ill.

Circle No. 338 on reply card

PRESSURE SWITCHES

These compact switches, measuring 4.30 x 2.62 in. and weighing less than 10 oz, use a Belleville spring for sensing pressure, vacuum, or differential pressure. Gage model operates in the 0-100 psi range. Vacuum model operates to −30 in. Hg. Differential unit has a range of 1-80 psi and operates through 1-125 psi. The 642G is priced at $33.50.—Custom Component Switches, Inc., Burbank, Calif.

Circle No. 339 on reply card

POWER SUPPLIES

CALIBRATES INSTRUMENTS

The EMV millivolt source is designed as a secondary laboratory standard for calibrating instruments that have high impedance inputs, such as potentiometer recorders. Supply uses a zener diode regulated circuit to provide highly regulated voltage adjustable in two ranges from 0 to 100 mv. Accuracy is to within 0.1 percent of full scale output, and noise output is as low as 0.1 millivolts across the output terminals or from either terminal to ground. Price: $175.—Westronics Inc., Ft. Worth, Tex.

Circle No. 340 on reply card

VARIABLE SOURCE

This new 50-watt power supply, Model LDS-1500, delivers continuously variable voltages of 0-1,500 volts at currents of 0-15 amp with any frequency between 20 and 20,000 cps. Harmonic distortion is only 0.1 percent with an amplitude stability to within 0.01 percent. Instrument is

←CIRCLE 132 ON READER SERVICE CARD

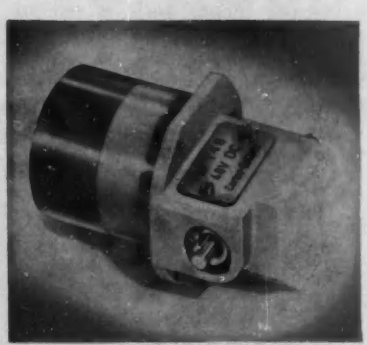
CIRCLE 133 ON READER SERVICE CARD

housed in a standard cabinet, 40 in. high. Price: $3,850. — Krohn-Hite Corp., Cambridge, Mass.
Circle No. 341 on reply card

TWO-WAY REGULATED

Either current or voltage regulation may be switch selected when using the TCV-40-10 solid state power supply. Working on input of 115 vac, single phase, the units produce 40 vdc with maximum current of 5, 10, 15, or 30 amp. For line change of ±10 percent, current regulation is to within 0.02 percent, and voltage regulation to within 0.01 percent. Price: $1,400. — Spectromagnetic Industries, Hayward, Calif.
Circle No. 342 on reply card

ACTUATORS & FINAL CONTROL ELEMENTS



IMPROVED VERSION

This redesigned miniature gear motor has better performance and longer life than the model it replaces. The TM-148 is more compact and uses an additional armature bearing. Operating on dc, the permanent magnet motor is available for use with input

A telephone call brings out the best in him

The dictionary lists twenty-two definitions for the word service. For Tony Arobone there should be a twenty-third.

In his ten years of sales engineering for K & M, Tony has evolved a very personal and particular notion of what service means. But we doubt if he could (or would) put it into words. He's a doer, not a talker.

His customers can tell you about it. Tony's the guy you call when you need help. That includes help in working out valve specs, hounding the factory to ensure on-time delivery, supervising installation and hook-up—even getting a replacement part for you in a hurry (his service doesn't end with the ringing-up of the sale).

Tony's readiness to assist customers in any and every way isn't simply a matter of knowing which side your bread is buttered on—although it is obviously good business. A former working engineer himself, Tony knows what it's like to bear project responsibility, and a good bit of his desire to be helpful can be ascribed to honest identification with the man on the other side of the desk. He has been in your shoes, and he knows they sometimes pinch.

Most K & M representatives are former practicing engineers. When you sit down with them to talk over a valving job, you'll find they speak your language.

K&M

KIELEY & MUELLER, INCORPORATED

64 Genung Street, Middletown, New York

Eighty-two Years of Service to the Process and Power Industries

CIRCLE 135 ON READER SERVICE CARD

BA-2409

voltages of 6, 12, 24, 28, 32, or 48 volts. Double gear reduction results in output speeds of 10-100 rpm at a maximum torque of 50 oz-in. Unit weighs 9 oz and measures 2 in. in diam by 2¾ in. List price: $63.50.—Carter Motor Co., Chicago, Ill.

Circle No. 343 on reply card

FOR PRECISE PROGRAMMING

This new series of electrohydraulic cylinders is designed to facilitate precise programming and automatic repetition of variable speed and stroke length operations. An integrally mounted transducer develops a proportional electrical signal when a cylinder is led through a series of strokes. These signals can be recorded on accessory equipment as shown above. The transducer also provides a feedback signal to monitor the repeated operations. The Series 80 cylinders can be mounted singly or compounded. A wide range of stroke lengths, bore sizes, rod ends, and mountings are available. Price: about $1,000.—Guerin Engineering, Inc., Ferndale, Mich.

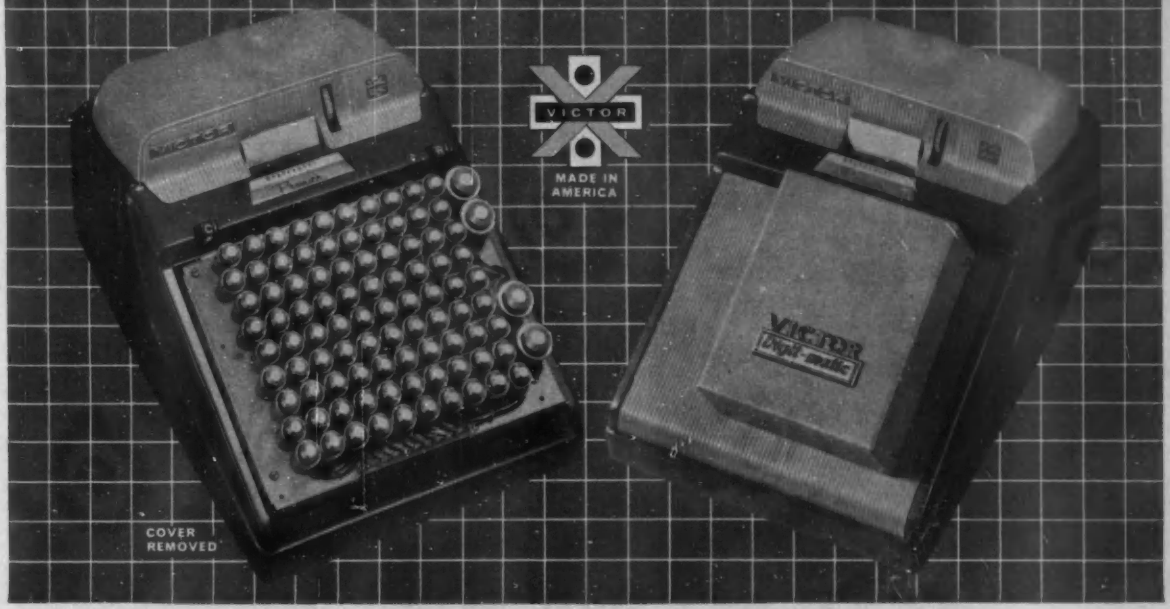
Circle No. 344 on reply card

COMPONENT PARTS

TINY LOGIC

Tradenamed Pico-Bit, these versatile subminiature (0.88 cu in.) logic packages are designed to perform any of nine basic functions: AND, OR, inhibit, branch, store, transfer, drive, binary count, and complement. The units maintain full performance and reliability from −55 to +125 deg C and under severe shock and vibration.

PROVED ULTRA-RELIABLE VICTOR DIGIT-MATIC PRINTERS



160,000,000 digit impressions without failure

Rugged, Trouble-Free—Digit-Matics are specially built to stand the strain of continuous operation. In a durability test, over 160 million digit impressions were made without breakdown or need of adjustment. The machine tested operated continuously, eight hours per day until 160 million digit impressions were made. During this period only normal lubrication and cleaning were performed.

Parallel or Serial Entry — Automatic and unattended, solenoid-activated Digit-Matics print out alpha-numeric data from remote equipment. High speed parallel entry models accept up to 10 digits at a time, print up to 4 lines per second. Serial entry models accept 1 digit at a time, up to 11 per line.

Two-Color Printing — Positive values in black, negative values in red. Ideal for "accept-reject" sequences, testing applications, accumulating data from two sources on one Digit-Matic, and many other uses.

Adaptable to Your Specific Needs — Line includes listers, accumulators and calculators. Versatile units can handle degrees, minutes, seconds, fractions. Other modifications: superimposed keyboard for manual use, time readings, counters, etc.

Immediate Field Service — 70 factory service branches and service representatives in over 600 cities assure uninterrupted operation. Victor offers 30-day delivery on most Digit-Matics. Mail coupon now for product data and application information.

VICTOR
ELECTRONICS DIVISION

Victor Adding Machine Co., Chicago 18, Illinois
Victor Adding Machine Co., (Canada) Ltd., Galt, Ont.

Manufacturers of Digit-Matic Printers, Scanning Printers, Electrical Keyboards, and Digit-Matic Data Punches

Victor Adding Machine Co. CE-8
Chicago 18, Illinois
Send full information on Victor Digit-Matics.

My application is_____

Name_____ Title_____

Company_____

Address_____

City_____ State_____

CIRCLE 137 ON READER SERVICE CARD 137

NEW PRODUCTS

Operating frequency limit is 250 kcps. Prices range from $50 to $125.—Di-An Controls, Inc., Boston, Mass.

Circle No. 345 on reply card

NEEDS NO SUPPLY

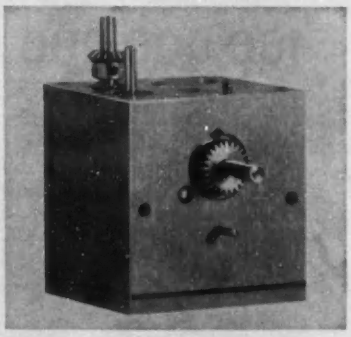
This improved design amplifier is made to operate directly from a 115-vac, 400-cps line. It also features 8-percent power efficiency, eliminating the need for a heat sink when operating in an environment of −55 to +125 deg C.

Characteristics:

Size: 1 x 1 x 3 in.
Power output: 3.5 watts
Input impedance: 7,500 ohms
Voltage gain: 150
Maximum output voltage: 57 vac.
Price: $150.
—Magnetic Amplifier Div., The Siegler Corp., Bronx, N. Y.

Circle No. 346 on reply card

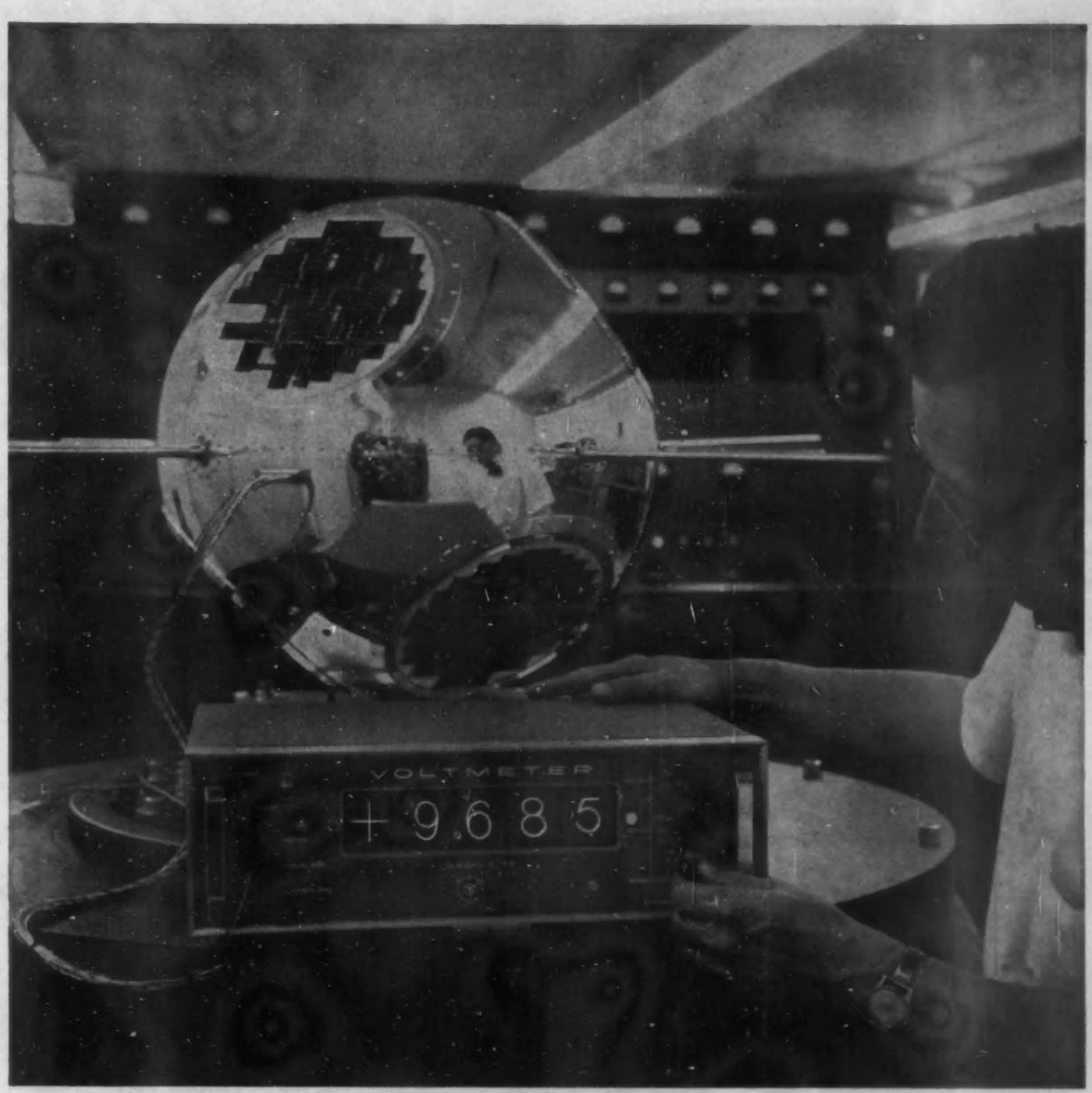
ACCESSORIES



COMPUTES CHART AREAS

Rapid computation of the area under a strip chart curve is possible using a newly announced Series 200 integrator. The unit features high count rates and blip readout. Count ranges from one to 3,000 per min are available. Integrator is said to be very stable: no zero drift or change in range takes place over a wide temperature range. Accuracy is to within ±0.1 percent full scale of the area under the curve. Peaks as sharp as ½ sec duration can be integrated without lag error. Price: $585.—Disc Instruments, Inc., Santa Ana, Calif.

Circle No. 347 on reply card



NEW DVM CONCEPT!

FAST: *Two readings per second* ***ACCURATE:*** *0.01% accuracy* ***LOW COST:*** *Only $1,580*

In the above test of a satellite's telemetry and solar cells, it was necessary to make 100 accurate measurements every minute. The job was done with the new Cubic V-70 digital voltmeter that reads out four times as fast as any instrument with stepping switches. The V-70 uses ultra-reliable reed relays hermetically sealed in glass for a life expectancy of at least 10 years. It has no moving parts, requires no maintenance, will operate in any position, and is resistant to thermal and physical shock. The V-70 is the only DVM offering 0.01% accuracy and less than 1 second balance time for less than $2,000 (Model V-70, $1,580; Model V-71 with automatic ranging and polarity, $2,200). For details, write to Dept. CT-107.

cubic CORPORATION
INDUSTRIAL DIVISION
SAN DIEGO 11, CALIFORNIA

OTHER OFFICES: LOS ANGELES, CALIFORNIA • ROME, ITALY (CUBIC EUROPA S.p.A.) • REPRESENTATIVES IN PRINCIPAL U.S. AND CANADIAN CITIES

CIRCLE 139 ON READER SERVICE CARD 139

WHAT'S NEW

(Continued from page 38)

U.S. Projects Use 76 Percent of Electronics Manpower

According to a survey recently released by the Electronic Industries Association, 76 percent of all U.S. engineers and scientists engaged in electronics work are supported by government funds.

The EIA put the total number of electronics engineers and scientists at 155,000. Industrial companies employ 83 percent of the total; 8 percent work for the government; 5 percent do research work for universities and nonprofit organizations. The rest are consultants, those between jobs, or those whose work is not identifiable by area of electronic activity.

News of Companies in the Control Field

Westinghouse Electric Corp. has formed a new department to develop and produce molecular electronics functional blocks. The new group will be a part of Westinghouse's Semiconductor Dept. in Youngwood, Pa., and will be headed by Fred M. Heddinger, former assistant general manager of the department. Dr. H. W. Henkels was named engineering manager of the new organization.

Astro-Science Corp. has purchased the Ground Support Div. of American Electronics, Inc. The division will operate as Astro-Systems, Inc., a division of the Los Angeles company. The cash transaction involved over $1 million.

Indiana General Corp., Valparaiso, was the successful bidder for the assets of the Eicor Div. of the Scranton Corp. The 23-year old Oglesby, Ill., firm manufactures special electrical motors and other rotary units, including motors for cooling and torque applications in EDP equipment.

Electrodynamic Instrument Corp. has been formed as a subsidiary by Reed Roller Bit Co. of Dallas, Tex. The new company has been set up to design and install process control equipment for pipelines and petrochemical plants.

Lionel Corp., has reached an agreement with Hathaway Instruments, Inc. for Lionel to acquire the multi-division company in a one-for-one stock exchange transaction. Hathaway's Denver Div. makes measuring and testing equipment; its Clemco

FOR THE ENGINEER

who can't sleep nights

If you're losing sleep over a sticky problem in automatic control, AE can help—because AE has a reputation for making things *work* automatically.

It's not surprising, considering our unique experience in the design of circuits and components for automatic telephone exchanges.

What's more, AE relays and stepping switches are unique in their own right—because they're built to have substantially zero variation in operating characteristics *for life.*

As an example: the AE Class B Relay, illustrated, provides hundreds of millions of operations with unfailing contact reliability, and seldom needs maintenance. For this reason, it is probably the most inexpensive relay you can use where infallibility is an essential.

AE relays and stepping switches are custom-made to *your* specifications—and are also available wired and assembled into complete control units. And we're always glad to suggest specialized circuits that may cut your end costs.

Want more information? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

Also yours for the asking: Circular 1702-E, *Relays for Industry,* and a new 32-page booklet on *Basic Circuits.*

AE CAN DO

AUTOMATIC ELECTRIC

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

GENERAL TELEPHONE SYSTEM

WHAT'S NEW

Aero Products Co., Inc. makes hydraulic and pneumatic actuators and controls; Sterling Electric Motors, Inc. produces motors and variable speed drives; Induction Heating Corp. specializes in heat treating equipment; and Dale Electronics, Inc. manufactures resistors and potentiometers.

Tescom Corp., of Minneapolis, Minn., has formed a new Fluid Systems Div. The division will design and produce systems and controls for regulation of high pressures. Tescom also recently became the parent corporation of Smith Welding Corp.

Control Logic, Inc. has been formed in Natick, Mass., to specialize in design and manufacture of data handling and control products and application services. President of the new firm is Samuel Bass; he and vice-presidents D. E. Deuitch and B. E. Peck were formerly with Epsco, Inc.

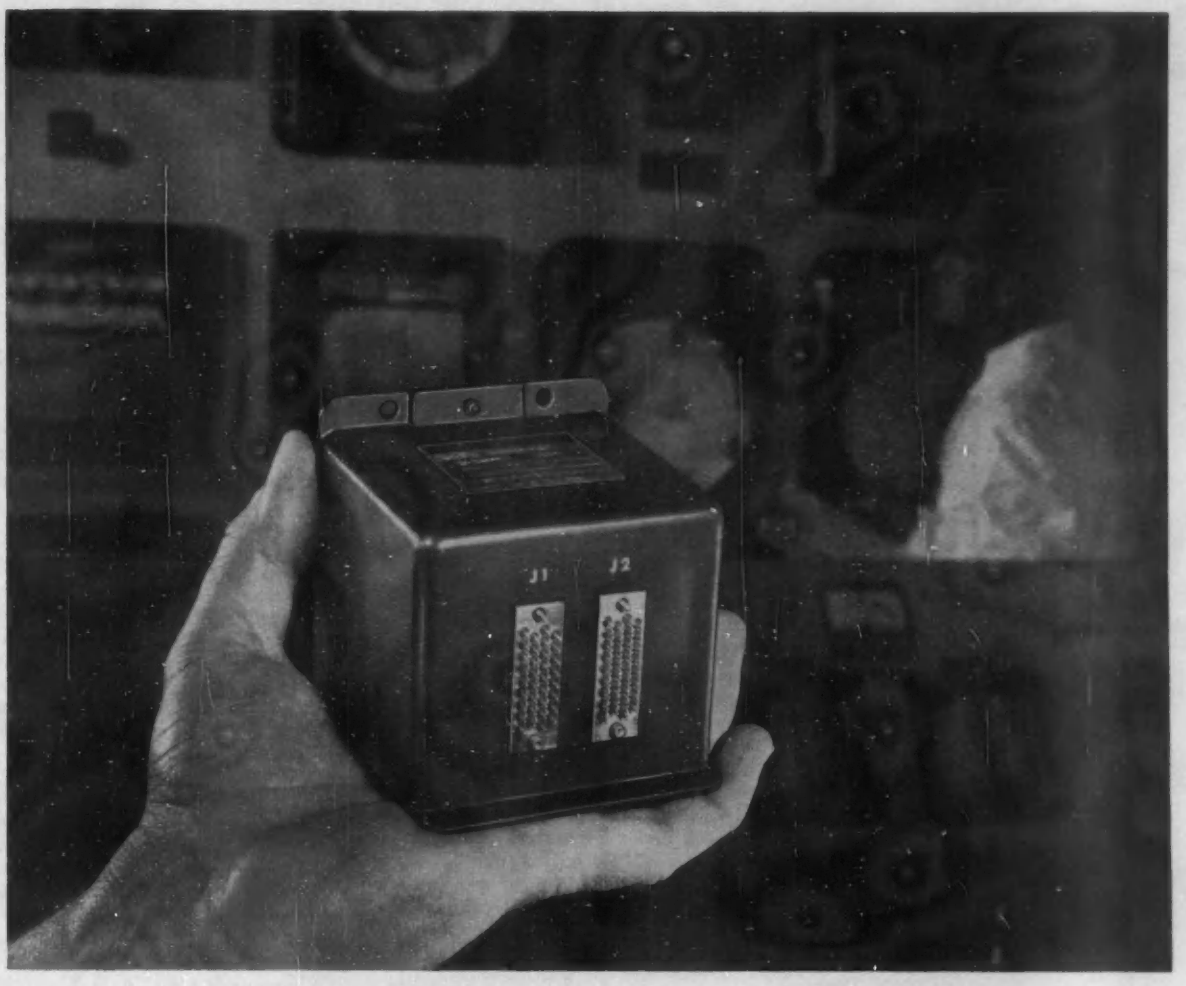
Rochester Instrument Systems, Inc. is a new company established in Rochester, N. Y., to produce electronic process control instruments and systems. Emphasis will be given to nuclear reactor instrumentation. President of the newly formed company is Donald D. Welt, who was with General Dynamics/Electronics.

Bowmar Instrument Corp., Ft. Wayne, Ind., has entered into merger negotiations with Technology Instrument Corp. of Acton, Mass. Bowmar would be the surviving corporation.

Dashew Business Machines, Inc. of Los Angeles has acquired Automated Sensory Devices, producer of punched card, paper tape, and edge punched card readers. The firm will now be known as Electronic Datacoupler, Inc. and will be operated as a wholly owned subsidiary of Dashew.

Instrument Systems Corp. has acquired GRH Halltest Corp. of Valparaiso, Ind., a manufacturer of a wide line of magnetic testing instruments based on Hall effect generators. Operations of Halltest have been moved to Instrument Systems' College Point, N. Y., facilities.

General Electric Co. has set up a nuclear control engineering unit within its Industry Control Dept. in Salem, Va. The group will design nuclear reactor control gear, especially for Navy propulsion reactors.



This Kinetics electronic commutator samples inputs more reliably, at higher speeds

For sampling a large number of inputs for automatic control or measurement systems, the Kinetics electronic commutator will do the job better than a rotary commutator, a rack of mercury-wetted relays, or other methods. The Kinetics static commutator offers advantages in reliability, speed, low noise, size, weight, power consumption and life.

These Kinetics signal transfer devices can be built to handle from .5 to 30 samples per channel per second or greater and are available with from 1 to over 200 channels. They are entirely solid-state, having no moving parts, and are built with rugged silicon semi-conductors which have been conservatively de-rated so as to operate well within manufacturer's specified limits. This insures long life and reliability. They can handle up to 20 volts full scale in currents from 10 to 50 microamperes. They are also capable of low level commutation such as use with strain gauges or other similar instrumentation applications.

The unique Kinetics design minimizes internal error voltage, thus insuring high fidelity signal transfer. Forecast life is in excess of 10,000 hours continuous operation.

Write for more information on this electronic commutator. Send your inquiry to Kinetics Corp., Dept. KC-8, 410 South Cedros Ave., Solana Beach, Calif. SKyline 5-1181.

Staff Positions:

ELECTROMECHANICAL PROJECT ENGINEERS

Our rapid growth has made staff positions available in R & D on electromechanical products. Complete responsibility from original design concept through production. MS or BS degree preferred. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Inquiries should be sent to Warren L. Smith, Staff Employment.

KINETICS
CORPORATION

ELECTRONICS · ELECTROMECHANICS

IMPORTANT MOVES BY KEY PEOPLE

Dr. Smith, Others Named in Honeywell EDP Reorganization

Dr. Ernest J. Smith (photo) has been named a vice-president of the Electronic Data Processing Div. of Minneapolis- Honeywell Regulator Co. He will be responsible for future research and development programs and scientific liaison with other Honeywell divisions. Dr. Smith had been director of the division's engineering department.

Honeywell named John W. Anderson to succeed Dr. Smith. Anderson had been manager of the company's inertial guidance plant in St. Petersburg, Fla.

Also named as vice-president for Honeywell EDP was John R. Lenox, formerly operations department director. He'll be responsible for manufacturing, industrial relations, plants and property, procurement, field service, systems test, and interdivisional manufacturing liaison. To succeed Lenox, Honeywell announced Frederick G. Miller as new manufacturing head.

Richard H. Bloch was appointed director of product planning, and Dr. Richard F. Clippinger was named technical advisor with responsibility for automatic programming.

The assignment of liaison responsibility, according to division president Walter W. Finke, underlines the importance of advance evaluation of industry trends in the determination of future products.

Bechard Leaves TRW to be ISI Engineering Director

Henry L. Bechard, formerly assistant to the general manager of TRW Computers Co., division of Thompson Ramo Wooldridge Products Co., has joined Information Systems, Inc. as director of engineering for the Systems Div. The Los Angeles company is a subsidiary of Chance Vought, Inc.

Bechard will direct ISI's engineering of large and medium sized computer systems for industrial process control. He'll also be responsible for the company's line of computer products.

At TRW, Bechard was involved in advance planning of computer systems. He was also with Daystrom Systems Div. as engineering director.

Other Important Moves

Paul J. Colleran has joined International Rectifier Corp., El Segundo, Calif., as vice-president for engineering. Colleran was with GE for the past 10 years and had been manager of advanced semiconductor engineering at the GE facility in Collingsdale, Pa., since 1952.

Wilson S. Pritchett has joined Hallikainen Instruments, Berkeley, Calif., as chief electrical engineer for instrument development and design. For the past four years Pritchett has been chief engineer of Knopp, Inc. Previously he was associate professor of electrical engineering at the University of California at Berkeley.

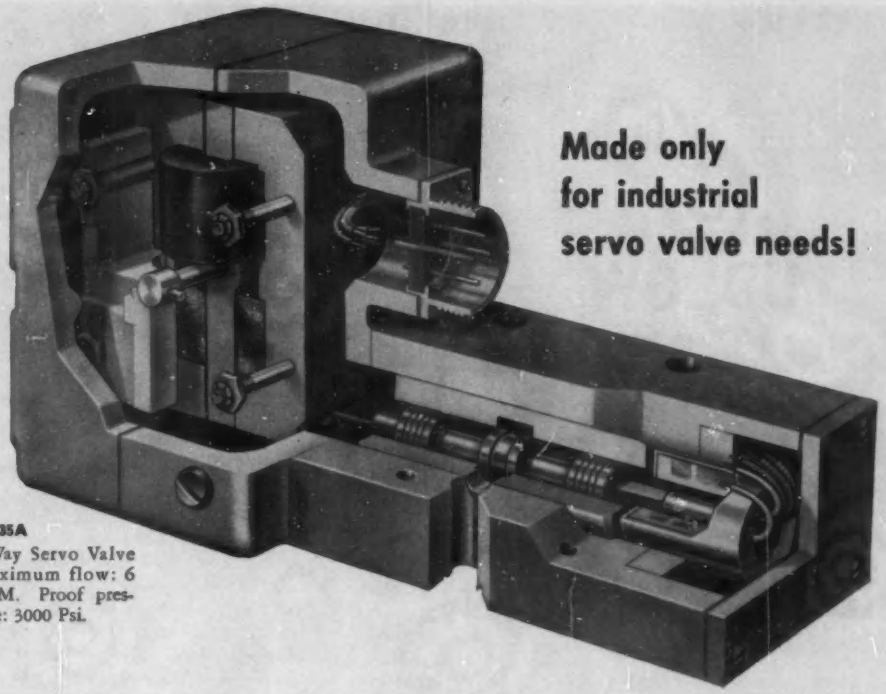
Seymour Harrison and **Norman Milkman** have joined Trak Electronics Co., Wilton, Conn., to form a new Data Processing Engineering Dept. Among the products to be investigated will be data display units. Harrison, engineering manager of the new unit, was manager of special systems engineering for Budd Electronics, Inc., subsidiary of the Budd Co. Milkman was with Budd Electronics as a senior project engineer for data processing equipment.

C. B. Blatchley has been appointed chief engineer of Schutte and Koerting Co., Cornwall Heights, Pa. He has been with S&K for 25 years.

Edgar G. Grant is now director of new product planning for the Military Electronics Div. of Daystrom, Inc. in Archbald, Pa. Grant has been with the division for nine years.

Edward A. Hebditch has become executive assistant to the president of Gulton Industries, Inc. He'll be in charge of corporate planning for the Metuchen, N.J., company. Hebditch was with Arthur D. Little, Inc.

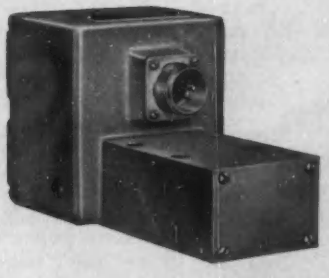
Dr. Sumner P. Wolsky will be director of the new laboratory of physical science to be established by P. R. Mallory & Co., Inc. in the Boston, Mass., area. The laboratory will specialize in thin films and semicon-



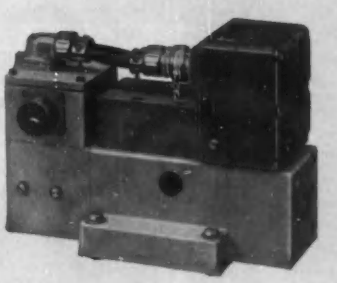
Made only for industrial servo valve needs!

V7835A
3-Way Servo Valve
Maximum flow: 6 GPM. Proof pressure: 3000 Psi.

V7837B
4-Way Servo Valve
Available in ranges from 50 cu. in/min. max. to 4 gals./min. max. at 1000 Psi. Proof pressure: 3000 Psi.



V7840A
2-Stage Servo Valve
Maximum flow: 40 gallons/minute at 1000 Psi. Proof pressure: 3000 Psi.



V7841A
2-Stage Servo Valve
Maximum flow: 15 gallons/minute at 1000 Psi. Proof pressure: 3000 Psi.

RUGGED HONEYWELL QUALITY

- ***HEAVY DUTY CONSTRUCTION***
- ***BUILT-IN FEED-BACK SYSTEM***

Honeywell offers you a complete line of electro-hydraulic servo valves designed to meet any industrial application, built to withstand all industrial environments.

Honeywell Servo Valves feature integral LVDT electrical feedback to give you the widest electronic "spring-rate" selection available. Their new rate action assures greater inner-loop stability. They have a low hysteresis, low threshold, high speed of response and almost infinite resolution. They are torque motor actuated and can be mounted in any position. And, they have *only one moving* part so that maintenance is practically eliminated.

Used with Honeywell amplifiers, commands, feedbacks, actuators and other complementary equipment in an all-Honeywell electro-hydraulic servo system, Honeywell Servo Valves provide dependable, efficient control of machines and processes.

For complete information about Honeywell Servo Valves, call your local Honeywell office. Or write Honeywell, Dept. CE 8-72, Minneapolis 8, Minnesota. *Sales and service offices in all principal cities of the world.*

Honeywell

First in Control

SINCE 1885

WHAT'S NEW

ductors. Dr. Wolsky had been with the Research Div. of Raytheon Co.

Robert L. Sink has taken the post of manager of engineering for the Military Electronic Computer Div. of Burroughs Corp. in Detroit. Sink has been with Consolidated Electrodynamics Corp. for the past 15 years.

Dale N. Woodford has become chief control engineer for the Spartan Electronics Div. of Spartan Corp. He will direct the Jackson, Mich., firm's activities in supervisory control.

Robert F. McCormick, of the Automatic Switch Co., has been elected president of the Fluid Controls Institute. Other officers elected at the institute's spring meeting in Sea Island, Ga., were Eric A. Bianchi, Mason-Neilan Div., Worthington Corp., first vice-president; Paul K. Rogers, Jr., Skinner Precision Industries, Inc., treasurer; and Howard J. MacDonald, Minneapolis-Honeywell Regulator Co., corporate secretary.

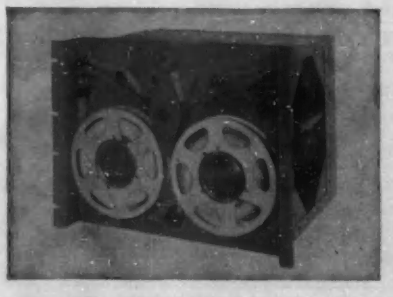
Rufus Oldenburger, professor of mechanical engineering at Purdue University, has been given the 1960 annual award of the Automatic Control Div. of the American Society of Mechanical Engineers. Prof. Oldenburger was cited for his solution of control problems using mathematics and mathematical shortcuts, for the successful planning and completion of the Frequency Response Symposium, and for his part in developing the International Federation of Automatic Control and the American Automatic Control Council.

James M. Cunnien is now director of engineering for Minneapolis-Honeywell Regulator Co.'s Precision Meter Div. in Manchester, N. H. Cunnien has been a project engineer there since 1959.

Clifford H. Shumaker, chairman of the Dept. of Industrial Engineering at Southern Methodist University, has been nominated president of the American Society of Mechanical Engineers. He'll take office next June following a mail ballot of members.

August Esenwein, who recently resigned as executive vice-president of Convair, has been elected president of Aerospace Industries Association. He replaces Gen. Orval R. Cook, who plans to resign at the end of this year.

...gives you greater reliability at less cost!



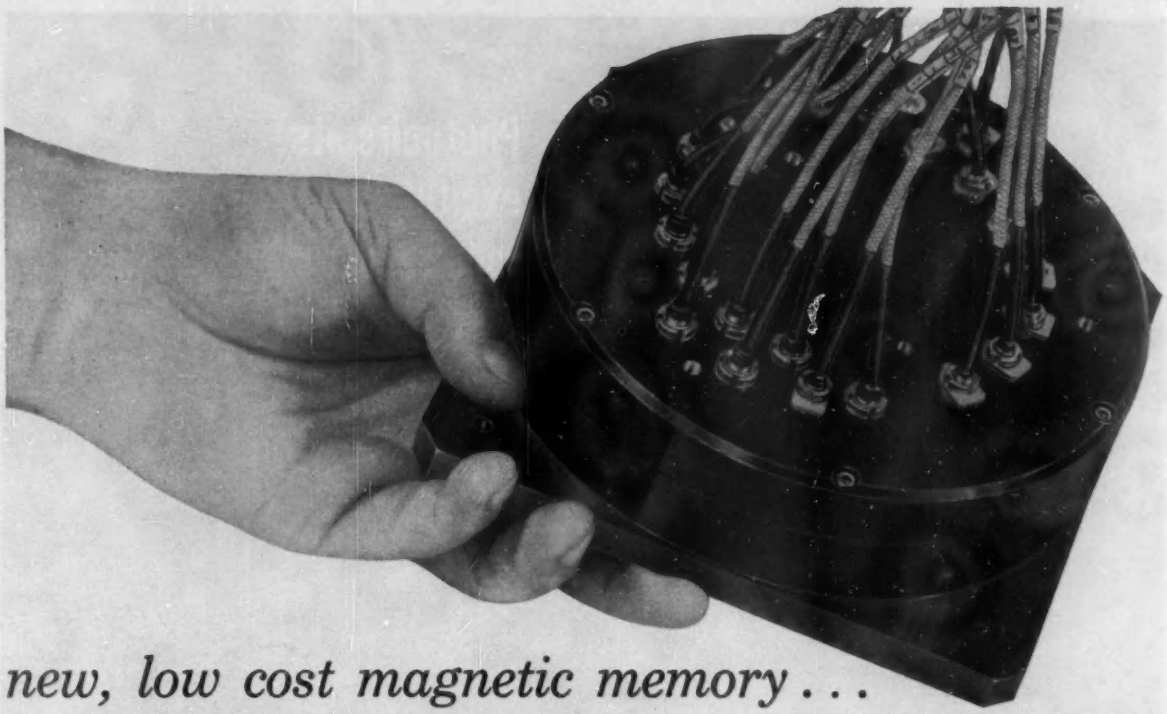
Using the revolutionary PMI printed motor, Photocircuits' line of Photoelectric Paper Tape Readers eliminates brakes, clutches, pinch rollers, solenoids — *and trouble.* Result: reliability that conventional readers can't match! Plus quieter operation, reduced tape wear, rapid reading and sustained trouble-free, error-free performance with maintenance at a minimum.

Photocircuits' readers offer you, at no additional cost—easy loading, jam-free operation over splices—tight tape and no tape protection—bi-directional reading—fast rewind in both directions—asynchronous reading at up to 300 characters per second—free running at 400 characters per second with the ability to stop on a character — and *magnetic switching,* which eliminates metal-to-metal contact in electrical switching of the reel servo motors.

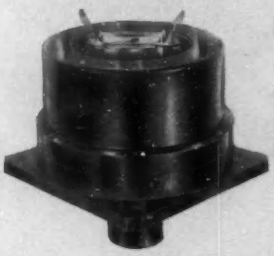
Technical literature on the 300 R and the other Photocircuits' readers is yours for the asking. Get all the facts about how Photocircuits' advanced Tape Readers can perform for you and save your company money at the same time.

Photocircuits
CORPORATION
TAPE READER DIVISION
GLEN COVE, LONG ISLAND, NEW YORK

CIRCLE 147 ON READER SERVICE CARD 147



new, low cost magnetic memory . . .
25,000 bit capacity . . . 5¾" x 5¾" x 5" . . . 5 pounds



The BD-10 Series is the latest addition to LFE's expanding line of Bernoulli Disk Memory Systems. It has been designed to fill the need for a low capacity, low cost storage device. It is available in single units for laboratory use, or in high volume production for use with all digital computers utilizing magnetic storage media.

A flexible Mylar magnetic disk, headplate, read/write heads and a precision motor are the basic components. Positive separation between disk and headplate is maintained by centrifugal force and the Bernoulli principle of fluid motion. The unit's low mass plus a cushion of air make damage to disk or read/write heads virtually impossible . . . even under the most severe environmental conditions. Write Marketing Manager, Computer Products Division, for prices and complete data.

SPECIFICATIONS BD-10 SERIES

Storage Capacity (max.) Bits	25,000
Disk Diameter (max.) Inches	4
Bits per Track (max.) @ 1½" radius	2,300
Bit Rate — kc	10-500
Track Layout As Required	
Typical:	
Total Tracks:	12
Data Storage Tracks	*
Spare Tracks	*
Clock and Timing Tracks	*
Register Tracks	*
Number of Registers	*
Register Length — Bits (minimum @ 2,300 B/T)	32
Register Adjustment — Bits	±3
Disk Speed — RPM Induction or Synchronous Motors Available	6,000-12,000
Power Source — cps	400
Magnetic Heads (Compatible with solid state circuits)	
Standard Heads	
Inductance (Per Leg. — C.T. Coil) uh	40, 55, 90
Write Current (O/P Manchester) ma (nominal)	125
Read Out (Min. P/P Full Coil) — mv (nominal)	20
Size — Inches	5¾ x 5¾ x 5
Weight — Pounds	5

*Wide variety of specifications can be provided to meet customer's requirements.

LFE
COMPUTER PRODUCTS DIVISION

LABORATORY FOR ELECTRONICS, INC.

1079 COMMONWEALTH AVE. • BOSTON 15, MASSACHUSETTS

See a demonstration at WESCON. August 22-25. Booths 2408-2410.

COMING NEXT MONTH

September CONTROL ENGINEERING devotes its pages to an in-depth treatment of a timely subject—SOLID STATE IN CONTROL—written and edited specifically from the control engineer's viewpoint:

- **Solid State Phenomena**
  Describes in engineering terms how basic solid state phenomena work and where they can be used in the control loop.
- **Measurement**
  Piezoelectricity, piezoresistivity, Hall effect, and photoconductivity can measure such variables as strain, power, and radiant energy.
- **Data Transmission**
  For ultra wide-band data transmission, lasers hold promise.
- **Decision and Storage**
  Newer solid state devices simplify logic and memory circuits for control. Cryotronics may be competitive soon.
- **Power Control**
  This 13-page section covers power transistors and silicon controlled rectifiers as on-off and continuous output elements, temperature control with thermoelectrics, and solid state power supplies.
- **Display**
  A report on electroluminescent display describes available devices.
- **Molecular electronics**
  Technology focuses on converting a piece of semiconductor into a functional electronic block.

Get YOUR own personal copy each month. Complete and mail this card TODAY!

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL
First Class Permit No. 43, (Sec. P. L. & R.) Ridgefield, Conn.

Reader Service Department 2 (8/61)

CONTROL ENGINEERING
P. O. Box 623
Ridgefield, Conn.

TURN PAGE
to Get More Information About

1. Advertised products
2. New product items
3. Catalogs and Bulletins
4. Article reprints

All advertisements, new products, and literature items are numbered for your convenience.

NEW SUBSCRIPTION APPLICATION CARD

(Subscriptions solicited only from engineers and technical management men)

Yes! I want my own personal copy of CONTROL ENGINEERING every month. Enter my subscription at once for 1 year at $3.* ☐ New ☐ Renewal

Check here ☐ for 3 years at $5 *

(*United States and Canada only. Overseas rates on request.)

☐ Payment enclosed ☐ Bill me ☐ Bill company

ON-
U

Name_____ Position_____

Home Address_____

City_____ Zone_____ State_____

Company Name_____

Product Manufactured or Service Performed by Company_____

BUSINESS ADDRESS

Street_____ City_____ State_____ Zone_____

☐ Check here if you want publication sent to business address

Please print — and fill out completely for best service

ON-RS-8/61

ADVERTISEMENTS *Mail Before November 1, 1961*

1	15	29	43	57	71	85	99	113	127	141	155	169	183	197	211	225	239	253	267	281	295
2	16	30	44	58	72	86	100	114	128	142	156	170	184	198	212	226	240	254	268	282	296
3	17	31	45	59	73	87	101	115	129	143	157	171	185	199	213	227	241	255	269	283	297
4	18	32	46	60	74	88	102	116	130	144	158	172	186	200	214	228	242	256	270	284	298
5	19	33	47	61	75	89	103	117	131	145	159	173	187	201	215	229	243	257	271	285	299
6	20	34	48	62	76	90	104	118	132	146	160	174	188	202	216	230	244	258	272	286	300
7	21	35	49	63	77	91	105	119	133	147	161	175	189	203	217	231	245	259	273	287	301
8	22	36	50	64	78	92	106	120	134	148	162	176	190	204	218	232	246	260	274	288	302
9	23	37	51	65	79	93	107	121	135	149	163	177	191	205	219	233	247	261	275	289	303
10	24	38	52	66	80	94	108	122	136	150	164	178	192	206	220	234	248	262	276	290	304
11	25	39	53	67	81	95	109	123	137	151	165	179	193	207	221	235	249	263	277	291	305
12	26	40	54	68	82	96	110	124	138	152	166	180	194	208	222	236	250	264	278	292	306
13	27	41	55	69	83	97	111	125	139	153	167	181	195	209	223	237	251	265	279	293	307
14	28	42	56	70	84	98	112	126	140	154	168	182	196	210	224	238	252	266	280	294	308

NEW PRODUCTS & BULLETINS

309	320	331	342	353	364	375	386	397	408	419	430	441	452	463
310	321	332	343	354	365	376	387	398	409	420	431	442	453	464
311	322	333	344	355	366	377	388	399	410	421	432	443	454	465
312	323	334	345	356	367	378	389	400	411	422	433	444	455	466
313	324	335	346	357	368	379	390	401	412	423	434	445	456	467
314	325	336	347	358	369	380	391	402	413	424	435	446	457	468
315	326	337	348	359	370	381	392	403	414	425	436	447	458	469
316	327	338	349	360	371	382	393	404	415	426	437	448	459	470
317	328	339	350	361	372	383	394	405	416	427	438	449	460	471
318	329	340	351	352	373	384	395	406	417	428	439	450	461	472
319	330	341	352	363	374	385	396	407	418	429	440	451	462	473

REPRINTS

474	485	496	507
475	486	497	508
476	487	498	509
477	488	499	510
478	489	500	511
479	490	501	512
480	491	502	513
481	492	503	514
482	493	504	515
483	494	505	516
484	495	506	517

Name _____ Title _____

Company _____

Address _____ City _____ Zone _____ State _____

Index of advertised equipment, new products, and bulletins. For additional information circle number on card corresponding to number to left of item.

1. SYSTEMS

Advertisements

15—Weighing, batching system, p. 15
19—Miniature process controls, p. 18
22—Inertial guidance system, p. 22
55—Process instrument line, p. 54
72—Message switching system, p. 72
91—Proven digital computer, p. 91
115—Packaged hydraulic systems, p. 115
127—Process, utility computer, p. 126
189—Transistorized digital systems, p. 169

New Products

319—Low cost robot arm, p. 114
320—Scientific desk computer, p. 114
321—Unique NC system, p. 114

Bulletins and Catalogs

410—Remote handling equipment, p. 157
412—Engine safety control, p. 157

2. DATA HANDLING AND DISPLAY EQUIPMENT

Advertisements

2—Paper to magnetic tape converter, p. 2
7—Dc to 5 kc readout unit, p. 7
14—Tracking board projector, p. 14
21—Large screen display console, p. 20
24—5 line/sec digital recorder, p. 24
28—Compact data acquisition unit, p. 28
32—Trace finding oscillograph, p. 32
37—Modular design tape unit, p. 37
41—NC machine tool program, p. 40
43—Decade counting tube, p. 43
48—Versatile potentiometer recorder, p. 48
50—Data reduction systems, p. 50
83—Versatile, reliable recorders, p. 83
116—Data collection unit, p. 116
117—Direct writing recorder, p. 117
131—Eight-channel oscillograph, p. 131
132—Versatile multichannel recorder, p. 132
137—Digital data printers, p. 137
140—Fast data printers, p. 140
164—Tape search, control units, p. 164
170—Low frequency signal generator, p. 170
173—Simple readout units, p. 173
179—Voltage-digital converter, 2nd cover
181—Digital tape handler, 4th cover

New Products

322—Four-voltage plotter, p. 114
323—Data collection equipment, p. 114
324—Binary encoding keyboard, p. 116
325—Random access storage file, p. 116

Bulletins and Catalogs

404—Data acquisition system, p. 156

3. RESEARCH, TEST, AND DEVELOPMENT EQUIPMENT

Advertisements

5—Universal counter-timer, p. 5
138—Strain gage instruments, p. 138
139—Accurate, low cost DVM, p. _
172—Automatic circuit tester, p. 172
185—Remembering counter-timer, p. 165

New Products

309-318—Automatic testing units, p. 113
326—Tumble rate tester, p. 120
327—Complex-waveform analyzer, p. 120
328—High sensitivity 'scope, p. 122

Bulletins and Catalogs

405—Universal system checker, p. 156
417—Measuring, checkout equipment, p. 157
419—Digital measuring instrument, p. 158

4. PRIMARY ELEMENTS AND TRANSDUCERS

Advertisements

1—Closed circuit TV camera, p. 1
53—Strain gage potentiometer recorder, p .52
62—Easy resetting counter, p. 62
106—Single axis accelerometer, p. 106
108—Potentiometer pressure sensor, p. 108
114—Fast delivery synchros, p. 114
129—High temperature sensors, p. 129
130—Mercury manometers, p. 130
133—Rugged pressure transducers, p. 133
134—Impulse counter, p. 134
136—Low pressure transducer, p. 136
142—Through flow rotameter, p. 142
162—Accurate pressure gages, p. 162
165—Pneumatic receiver-recorder, p. 165
166—Air flow sensors, p. 166
169—Incremental position transducers, p. 169
180—Compact, large numeral counters, 3rd cover
183—Precise angle measurement unit, p. 161
188—A/D converter, p. 168

New Products

329—Pressure cell for tough duty, p. 122
330—Capacitance level indicator, p. 124
331—High-pressure sensor, p. 124
332—Sensitive level pickup, p. 128
333—Small rate gyro, p. 128
334—Incremental encoder, p. 128
335—1,000-rpm tachometer, p. 128

Bulletins and Catalogs

408—Floated rate gyros, p. 156

5. RELAYS, SWITCHES, AND CONTROLLERS

Advertisements

6—Stepping switch, p. 6
9—New industrial switch lines, p. 8

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed In The United States

POSTAGE WILL BE PAID BY

McGRAW-HILL PUBLISHING CO., Inc.

CONTROL ENGINEERING

330 WEST 42nd STREET

NEW YORK 36, N. Y.

6. POWER SUPPLIES

7. ACTUATORS AND FINAL CONTROL ELEMENTS

8. COMPONENT PARTS

9. ACCESSORIES AND MATERIALS

ADVERTISEMENTS — *Mail Before November 1, 1961*

1	15	29	43	57	71	85	99	113	127	141	155	169	183	197	211	225	239	253	267	281	295
2	16	30	44	58	72	86	100	114	128	142	156	170	184	198	212	226	240	254	268	282	296
3	17	31	45	59	73	87	101	115	129	143	157	171	185	199	213	227	241	255	269	283	297
4	18	32	46	60	74	88	102	116	130	144	158	172	186	200	214	228	242	256	270	284	298
5	19	33	47	61	75	89	103	117	131	145	159	173	187	201	215	229	243	257	271	285	299
6	20	34	48	62	76	90	104	118	132	146	160	174	188	202	216	230	244	258	272	286	300
7	21	35	49	63	77	91	105	119	133	147	161	175	189	203	217	231	245	259	273	287	301
8	22	36	50	64	78	92	106	120	134	148	162	176	190	204	218	232	246	260	274	288	302
9	23	37	51	65	79	93	107	121	135	149	163	177	191	205	219	233	247	261	275	289	303
10	24	38	52	66	80	94	108	122	136	150	164	178	192	206	220	234	248	262	276	290	304
11	25	39	53	67	81	95	109	123	137	151	165	179	193	207	221	235	249	263	277	291	305
12	26	40	54	68	82	96	110	124	138	152	166	180	194	208	222	236	250	264	268	292	306
13	27	41	55	69	83	97	111	125	139	153	167	181	195	209	223	237	251	265	269	293	307
14	28	42	56	70	84	98	112	126	140	154	168	182	196	210	224	238	252	266	280	294	308

NEW PRODUCTS & BULLETINS — **REPRINTS**

309	320	331	342	353	364	375	386	397	408	419	430	441	452	463		474	485	496	507
310	321	332	343	354	365	376	387	398	409	420	431	442	453	464		475	486	497	508
311	322	333	344	355	366	377	388	399	410	421	432	443	454	465		476	487	498	509
312	323	334	345	356	367	378	389	400	411	422	433	444	455	466		477	488	499	510
313	324	335	346	357	368	379	390	401	412	423	434	445	456	467		478	489	500	511
314	325	336	347	358	369	380	391	402	413	424	435	446	457	468		479	490	501	512
315	326	337	348	359	370	381	392	403	414	425	436	447	458	469		480	491	502	513
316	327	338	349	360	371	382	393	404	415	426	437	448	459	470		481	492	503	514
317	328	339	350	361	372	383	394	405	416	427	438	449	460	471		482	493	504	515
318	329	340	351	362	373	384	395	406	417	428	439	450	461	472		483	494	505	516
319	330	341	352	363	374	385	396	407	418	429	440	451	462	473		484	495	506	517

Name *Title*

Company

Address *City* *Zone* *State*

ADVERTISEMENTS — *Mail Before November 1, 1961*

1	15	29	43	57	71	85	99	113	127	141	155	169	183	197	211	225	239	253	267	281	295
2	16	30	44	58	72	86	100	114	128	142	156	170	184	198	212	226	240	254	268	282	296
3	17	31	45	59	73	87	101	115	129	143	157	171	185	199	213	227	241	255	269	283	297
4	18	32	46	60	74	88	102	116	130	144	158	172	186	200	214	228	242	256	270	284	298
5	19	33	47	61	75	89	103	117	131	145	159	173	187	201	215	229	243	257	271	285	299
6	20	34	48	62	76	90	104	118	132	146	160	174	188	202	216	230	244	258	272	286	300
7	21	35	49	63	77	91	105	119	133	147	161	175	189	203	217	231	245	259	273	287	301
8	22	36	50	64	78	92	106	120	134	148	162	176	190	204	218	232	246	260	274	288	302
9	23	37	51	65	79	93	107	121	135	149	163	177	191	205	219	233	247	261	275	289	303
10	24	38	52	66	80	94	108	122	136	150	164	178	192	206	220	234	248	262	276	290	304
11	25	39	53	67	81	95	109	123	137	151	165	179	193	207	221	235	249	263	277	291	305
12	26	40	54	68	82	96	110	124	138	152	166	180	194	208	222	236	250	264	268	292	306
13	27	41	55	69	83	97	111	125	139	153	167	181	195	209	223	237	251	265	269	293	307
14	28	42	56	70	84	98	112	126	140	154	168	182	196	210	224	238	252	266	280	294	308

NEW PRODUCTS & BULLETINS — **REPRINTS**

309	320	331	342	353	364	375	386	397	408	419	430	441	452	463		474	485	496	507
310	321	332	343	354	365	376	387	398	409	420	431	442	453	464		475	486	497	508
311	322	333	344	355	366	377	388	399	410	421	432	443	454	465		476	487	498	509
312	323	334	345	356	367	378	389	400	411	422	433	444	455	466		477	488	499	510
313	324	335	346	357	368	379	390	401	412	423	434	445	456	467		478	489	500	511
314	325	336	347	358	369	380	391	402	413	424	435	446	457	468		479	490	501	512
315	326	337	348	359	370	381	392	403	414	425	436	447	458	469		480	491	502	513
316	327	338	349	360	371	382	393	404	415	426	437	448	459	470		481	492	503	514
317	328	339	350	361	372	383	394	405	416	427	438	449	460	471		482	493	504	515
318	329	340	351	362	373	384	395	406	417	428	439	450	461	472		483	494	505	516
319	330	341	352	363	374	385	396	407	418	429	440	451	462	473		484	495	506	517

Name *Title*

Company

Address *City* *Zone* *State*

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL
First Class Permit No. 43, (Sec. P. L. & R.) Ridgefield, Conn.

Reader Service Department 1 (8/61)

CONTROL ENGINEERING
P. O. Box 623
Ridgefield, Conn.

For Information on Advertisements and Editorial Items

1. *Circle number on card that coincides with key number listed at bottom or adjacent to item of interest.*
2. *Fill in your name, title, company, and address.*
3. *Mail card immediately.*

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL
First Class Permit No. 43, (Sec. P. L. & R.) Ridgefield, Conn.

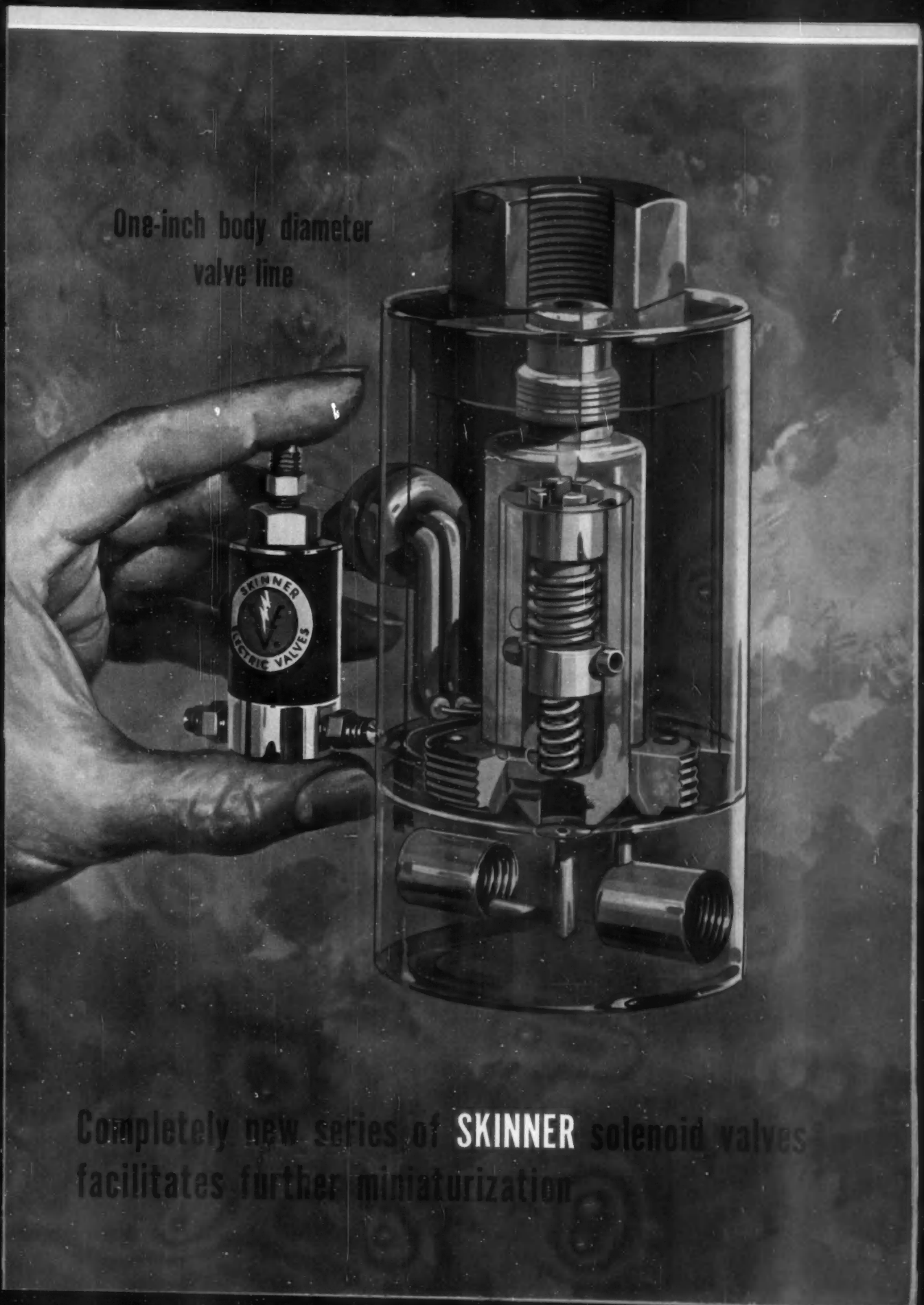
Reader Service Department 3 (8/61)

CONTROL ENGINEERING
P. O. Box 623
Ridgefield, Conn.

ORDER ARTICLE REPRINTS FROM THIS LIST

- *Circle reprint numbers on card for single copies. Write Reprint Dept. for multiple copies.*
- *See page 172 for descriptions of reprints.*
- *Don't send cash, we will bill you later.*

512—Ready Reference Data Files—IV, 50 cents (see also 500, below)
511—Industrial Process Chromatographs, 50 cents
510—The Use of Digital Computers (an old reprint with valuable content), $3.00
509—Applying Incremental Servos for Control, 65 cents
508—Transistor Switches for Industrial Service, 65 cents
507—Tips on the Use of Electromechanical Relays, 65 cents
506—Adaptive Control Systems, 50 cents
505—Optimizing Relay Servos, 50 cents
504—System Characteristics of Guidance Techniques, 65 cents
503—Stream Analyzer Dynamics, 40 cents
502—Survey of Dynamic Display Techniques, 50 cents
501—Six Transducers for Precision Position Measurement, 30 cents
500—Ready Reference Data Files—I, II, III, $1.35
499—Ready Reference Data Files—III, 60 cents
498—Ready Reference Data Files—II, 50 cents
497—Ready Reference Data Files—I, 50 cents
496—How to Specify Instrument Accuracy, 40 cents
494—How to Use the Root Locus in Control Design, 45 cents
489—Fundamentals of Multivibrators, 45 cents
488—A Roundup of Control System Test Equipment, 60 cents
487—Survey of Ac Adjustable Speed Drives, 50 cents
486—A New Way to Select the Best Control Valve, 50 cents
485—Fundamentals of Tie-Motor Control, 30 cents
484—How to Use Phase-Plane Techniques, 50 cents
483—Economics in Control, 50 cents
480—Applying Control Timers, 50 cents
478—Servo Modulators, 65 cents
477—Basic Data on Process Control Systems, 50 cents
476—Three Ways to Simulate Dead Time, 15 cents


One-inch body diameter
valve line
SKINNER
ELECTRIC VALVES
Completely new series of SKINNER solenoid valves
facilitates further miniaturization

Here's a really miniature stainless steel solenoid valve with all the features of a larger valve

think small

- Now designers of pneumatic and hydraulic control systems and devices requiring high flow in smaller packages can **specify miniature solenoid valves from shelf stock.**
- These new B Series valves are so small and so new that ⅛" NPT was too large, therefore 1/16" PTF connections were selected. Fittings are included to make fluid connections with ⅛" tubing.
- Never before have there been valves like this—**really miniature in over-all size, pipe size, and weight.**

VITAL STATISTICS

Type	3-way normally closed
Over-all size	1" x 2 1/16"
Orifice size	3/64" Inlet and Outlet
C_v factor	.045
Fluid connections	1/16" PTF (adapted for ⅛" tubing)
Weight	5 oz.
Maximum operating pressure	150 PSI
Vacuum	Down to 5 microns

Skinner Distributors are now stocking the first of these new valves—the three-way normally closed. Three-way normally open and directional control, two-way normally open and normally closed, and higher pressure models will be on the market soon.

For complete information contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

B SERIES FEATURES

No leakage—Soft, synthetic inserts provide bubbletight sealing. Seats have smooth rounded edges—no cutting of insert material.

Mounting by means of two tapped mounting holes (8-32) in valve body. Can be mounted in any position.

Voltage—Coils available in most AC and DC voltages. Heat rise meets U.L. standard of 85°C maximum for continuous duty. Maximum power requirement—7 watts.

Electrical housings are available with single grommet or ¼" NPT conduit which can be rotated 360°.

Media—B Series valves may be used with all common media including many semi-corrosive fluids.

Corrosion-resistant—Stainless steel body and internal parts.

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION
SKINNER PRECISION INDUSTRIES, INC. • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.

CATALOGS AND BULLETINS

The first three items in this section are examples of especially useful applications literature. Direct request is required for the first, and a charge is made.

Tunnel diodes

Following the pattern set by its widely used Transistor Manual, this manufacturer has now published a 96-page Tunnel Diode Manual. Theory and characteristics of tunnel diodes are described in detail, and circuit application information covering amplifiers, oscillators, switches, and logic circuits is included. Test circuits are treated extensively. Complete specifications are given for available units. Price: $1.—General Electric Co., Semiconductor Products Dept., Liverpool, N.Y.

Electromechanical units

This thumb-indexed publication was designed as a handbook to assist in selecting and applying clutches, brakes, torque indicators, torque standards, and multispeed transmissions. It covers a standard line, a pancake series, industrial miniature components, and special products. The above four sections are color-keyed, and particular components are tab-indexed in this 60-page Manual No. 361. Data sheets list specifications and dimensions and include photographs and performance curves. A 16-page section on engineering and application information describes the operation of the devices.—Autotronics, Inc. **Circle No. 400.**

Nuclear measurement

More than 250 instruments, counting systems, radionuclides, and nuclear accessories are described in this easy-to-read two-color catalog. Almost half of the 96-page publication is devoted to products that are new since the company's latest catalog was issued two years ago. Profusely illustrated, Catalog S gives complete specifications for all equipment; full descriptions of each instrument in use are also included.—Nuclear-Chicago Corp. **Circle No. 401.**

PLANAR SEMICONDUCTOR. Fairchild Semiconductor Corp. Brochure, 12 pp. Full color presentation is used to great advantage to describe in detail the planar semiconductor process in which semiconductor devices are given a surface junction protective oxide. Large magnification color photographs with accompanying color drawings show how the structure is evolved. Reliability, performance, cost, and adaptibility of the planar devices are covered, and performance comparison of planar and mesa units is given. **Circle No. 402.**

CORROSIVE-MEDIUM VALVES. Valcor Engineering Corp. Catalog Manual No. 108, 16 pp. Provides a handy means of selecting solenoid valves for corrosive applications. First page gives cutaway drawings and description of the valve series. A list of chemicals gives a key number—in color—for choosing the proper valve. Valve selection charts are keyed with the color

number for easy selection and include prices, material description, and other data. Dimension drawings and a flow vs pressure drop chart are included. **Circle No. 403.**

DATA SYSTEMS. Systems Div., Beckman Instruments, Inc. Bulletin 3017-B, 8 pp. Two-color block diagrams and photographs are used to describe the manufacturer's Model 210 data acquisition and processing system. Text describes how a typical system works and outlines the main features of the equipment. Complete technical specifications are included, and short histories of four typical applications are given. **Circle No. 404.**

UNIVERSAL TESTER. Radiation, Inc. Bulletin RAD G100, 8 pp. Covers the Model 301 universal automatic test equipment designed for total system checkout and adaptable electronic system troubleshooting. Block diagram and accompanying description gives configuration and operation of a typical 301 system. Photographs and short descriptions cover the elements of a test setup. **Circle No. 405.**

MINIATURE PUSHBUTTONS. General Electric Co. Bulletin GEA-7127A, 12 pp. This revised booklet covers the company's recently introduced line of miniature oil-tight pushbuttons, including several new forms. Full color photographs show color combinations and the added flexibility now available. Space savings over standard size switches are demonstrated, and cutaway drawings show construction features. Other photos show each type of operator, and accompanying tables and contact drawings cover versions available. Complete dimension drawings are included. **Circle No. 406.**

TOROIDAL CORE DESIGN. Wallace E. Connolly & Co. Design handbook, 14 pp. Contains basic design information on Genalex toroidal cores. Two-color curves of total core loss resistance vs frequency, hysteresis, incremental permeability, change of inductance with flux density, and Q vs frequency are featured. Tables list available Genalex cores and American Metal Powder Association standard types. **Circle No. 407.**

FLOATED GYROS. Kearfott Div., General Precision, Inc. Brochure, 8 pp. Describes KING series of inertial navigation gyros, said to be the most accurate of their size and weight now available. Photographs, dimension drawings, and wiring diagrams of the floated rate integrating gyros are included. Complete description is given of a three-position servo test and a six-position rate test including charts of typical test results. Characteristics of the four gyros in the series are given in a table. **Circle No. 408.**

RELIABILITY SAMPLING. Raytheon Co., Semiconductor Div. Nomograph. Quick computation of the acceptance number for any semiconductor sampling plan is possible with this reliability nomograph. Semiconductor user can predict the success rate from live test data at a 90-percent confidence level and can compute a sampling plan for conventional risks. Scales and tables with complete instructions are on heavy card stock. A glossary of reliability terms is also included. **Circle No. 409.**

REMOTE HANDLERS. General Mills, Inc. Booklet, 24 pp. Two-color publication uses photographs, sketches, and line drawings to describe applications of a line of remotely controlled mechanical arms. Detailed specifications and capacities of six standard models now available are included. **Circle No. 410.**

CHART CHANGER. Barton Instrument Corp. Bulletin 266-1, 4 pp. Uses sequential photographs to describe operation of automatic circular chart changer. Construction features, installation techniques, and ordering instructions are included. **Circle No. 411.**

PNEUMATIC SAFETY CONTROL. Fulton Sylphon Div., Robertshaw-Fulton Controls Co. Catalog J, 50 pp. Gives complete information on an all-pneumatic engine safety control system, including descriptions of a number of complete systems. These systems involve shutdown or warning based on off-limit conditions in temperature, pressure, level, speed, or vibration. System components such as relays, indicators, and receivers are described fully. **Circle No. 412.**

FLOW SWITCHES. The Henry G. Dietz Co., Inc. Catalog, 30 pp. Gives specifications, performance details, and prices on low pressure and fluid actuated flow switches. Photographs and dimension drawings are included for each unit. **Circle No. 413.**

THERMOCOUPLE MATERIALS. Temptron, Inc. Brochure, 10 pp. Covers line of metallic sheathed ceramic insulated thermocouple wire. Complete descriptions of the insulation and wire are given, including chemical composition of the insulation and reproducibility standards of the wire. Complete ordering information and tables of available types are included, and company facilities are described to demonstrate calibration and standardization. **Circle No. 414.**

PHOSPHOR, PHOTOCATHODE CHARACTERISTICS. ITT Federal Laboratories. Slide chart. Designed for engineers who work with cathode ray tubes, storage tubes, displays or phototubes, this slide chart provides a handy reference to the pertinent characteristics of 23 different phosphors and 14 of the most common cathode materials Much of the material is said to be unavailable elsewhere. **Circle No. 415.**

LASER FLASH TUBES. General Electric Co., Photo Lamps Dept. Booklet, 4 pp. Describes how standard photographic flash tubes may be used for driving lasers, at least until more efficient special devices are developed. Typical setups involving the use of several standard flash tubes are described, and circuit diagram is included. **Circle No. 416.**

INSTRUMENTS CATALOG. Dymec Div., Hewlett-Packard Co. Catalog, 16 pp. Technical information on products in three major areas are included in this two-color illustrated catalog. One section covers programmable digital systems for data handling, component testing, and automatic measurement and control. A second covers RF checkout equipment for production and field testing. The third includes special purpose test and measurement equipment. Complete specifications

Bulletins & Catalogs

including prices are given for each equipment item. **Circle No. 417.**

VALVE SIZER. Fulton Sylphon Div., Robertshaw-Fulton Controls Co. Slide rule. Simplification in the job of sizing control valves for known flow and pressure conditions is possible using this new slide rule. The rule solves for C_v and corrects for steam quality, gas specific gravity and temperature, and liquid specific gravity and viscosity. Standard A, B, C, and D slide rule scales are also provided. Step-by-step instructions are included. **Circle No. 418.**

DIGITAL MEASUREMENT. Computer Measurements Co. Data file, 10 pp. Describes an all-purpose digital measuring system built around a universal counter-timer. Called the DME (Digitally Measures Everything), the system measures dc volts, ac volts, resistance, frequencies, period, frequency ratio, and time interval. Booklet gives photographs of the component units and block diagrams of the system along with complete specifications for the instruments. **Circle No. 419.**

COPPER CLAD LAMINATES. Westinghouse Electric Corp., Micarta Div. Brochure B8215, 8 pp. Compares physical and electrical properties of seven grades of copper clad laminates for printed circuits. Tables list test methods and test results. A general description table gives recommended applications and special features and advantages of each type, including five paper base phenolic grades and glass and paper base epoxy types. **Circle No. 420.**

CONTACT PROTECTION. Presin Co., Inc. Rifa Bulletin, 12 pp. Shows how the use of low cost resistor-capacitor units made available by the Swedish manufacturer, Aktiebolaget Rifa, will increase relay contact life in even standard applications. Dimension drawings, photographs, and complete technical descriptions are given. Also included is a reprint from a lab publication describing this technique of relay protection. **Circle No. 421.**

INDUCTION MOTORS. General Electric Co. Bulletin GEA-7300, 6 pp. Covers the manufacturer's complete line of fractional horsepower specialty motors running from 15 mhp to ½ hp. Photographs and dimension drawings are given for the 3, 3⅞, and 4⅞-diam frame induction motors. Motor cutaway photo shows internal features. Performance curves and tables of available models complete the coverage. **Circle No. 422.**

SELENIUM CELL. Daystrom, Inc., Weston Instrument Div. Bulletin 03-201-A, 6 pp. Describes the features and applications of an improved design selenium photovoltaic cell. Photographs, dimension drawings, and descriptions are given for available units, and output curves are also included. **Circle No. 423.**

CRYOGENIC DATA. Cryogenic Engineering Co. Data Card. Said to be the first collection of this type of data on a simple reference card, this publication includes 11 physical properties of 31 cryogenic fluids. Also given are the thermal characteristics of seven insulations, conversion factors, and special properties of certain fluids. **Circle No. 424.**

Cost Cutting Combo

for Thermocouple Extension Wire Installations

Here's an economy team to increase efficiency and cut costs up to 75% in your next thermocouple extension wire installation. Multi-conductor THERMO-CABLE* permits you to install from 6 to 56 pairs of color-coded, insulated thermocouple leads, at one time, using just one cable. Terminate the wires in a weatherproof multi-terminal box specifically designed for THERMO-CABLE.

No more pulling individual leads through conduit. And, THERMO-CABLE, with its polyvinyl chloride weatherproof, heat and corrosion resisting outer sheath often eliminates the need for conduit. Direct burial types available to eliminate hazards from fire and mechanical damage.

T.E. weatherproof Terminal Boxes are made of cast iron or sheet steel, can accommodate from 6 to 100 circuits, and offer sure protection against the effects of contaminating atmospheres. Made to N.E.M.A. or JIC specifications.

Write today for Catalog 83-11

*Trade Mark

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

CIRCLE 182 ON READER SERVICE CARD

0.1% LINEAR OUTPUT OVER TEMPERATURE RANGE

SIZE 11 DC TACHOMETERS

These Kearfott DC tachometers are unusually durable and specifically designed to provide reliable service over a long life. R9608-001 is an uncompensated unit ideally suited to function as a stabilizing element in a standard DC servomechanism. The R9608-002 model offers the precision required in computing applications and is temperature compensated to maintain its high accuracy over the temperature range of −15°C to +71°C, with variations of no more than .1% of values specified at 25°C.

		R9608-001	R9608-002
TYPICAL ELECTRICAL DATA	Output (volts/1000 rpm)	7 (typical) .5-30 available	2
	Rated Speed (rpm)	3600	5000
	Linearity (% to 3600 rpm)	.07	.1
	Winding Resistance (ohms)	125	
	Output Impedance (ohms)	—	36
	Ripple Voltage	2% above 100 rpm	2.5% at 3600 rpm
TYPICAL MECHANICAL DATA	Friction Torque (in. oz.)	0.25	0.25
	Rotor Moment of Inertia ($gm\text{-}cm^2$)	7	8
	Weight (oz.)	5.5	5

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.
Little Falls, New Jersey

CIRCLE 159 ON READER SERVICE CARD

ABSTRACTS

Automatic central library

From "A Library for 2000 A. D.", by John G. Kemeny, Chairman of the Mathematics Dept., Dartmouth College. One of a series of lectures sponsored by the MIT School of Industrial Management, Cambridge, Mass., March 27, 1961.

By the end of this century our university libraries will be obsolete. The library of the future must miniaturize books and periodicals and put them on a medium that is easily handled by machines. A central National Research Library can be built to serve both the Federal Government and the major universities at minimum cost—under one billion dollars for planning and construction.

The proposed library will start with some 10 million volumes and may grow to 300 million by the end of the 21st century. Material will be divided into 100 subjects, each growing by some 6×10^4 items per year in 2000 A.D. (pure mathematics would make one subject, chemistry five). Subjects will be divided into up to 100 branches. Within a branch, material may be classified into books and books into items (a chapter of a book or an article in a journal). Each item can then be cataloged by a code name consisting of 3 letters and 9 digits.

If each page is stored on a 1 mm square area of tape, all the pages of an item can be stored across the width of a 2-in. tape, and such a tape 3,300 ft long will handle a branch with up to 10^9 items. Each subject will have a room with some 100 tape machines, one for each branch. Each subject can be closed down one day a month while new material is added.

The system will work something like this: Users at their own universities have access to reading units connected to the central library. The reading units are capable of receiving, recording, and displaying pages, and have a means of signaling the library. The user simply dials the code number of the item he desires or signals for a subject catalog. When an item is requested it is read from the storage tape into a projection unit that transmits it to a tape in the reading unit. Once the item is received, the user hangs up and can read the item at leisure. The average user should not tie down the storage unit for more than a minute or two. Relevant parts of the central catalog can also be copied onto the reading tape so that the catalog is not tied up while the customer searches.

ABSTRACTS

Endless belt behavior

From "The Temporal Behavior of an Endless Elastic Track between Successive Rollers, Part I," by G. Kessler. Regelungstechnik, December 1960, pp. 436-439. In German.

Endless threads and other members continuously passing through machinery are subjected to stretching and stressing forces that are essentially dependent upon the circumferential speed of the driving cylinders. The author shows how to calculate the static and dynamic behavior of the length and the stretch and stress of an elastic member for various arrangements with the member freely movable or running under tension in a predetermined path.

High G testing

From "Use of a Centrifuge for the Precision Measurement of Accelerometer Characteristics", by S. R. Sporn, Arma Div., American Bosch Arma. Paper No. 60-WA-195 presented at the Winter Annual Meeting of the American Society of Mechanical Engineers, New York City, Nov. 27-Dec. 2, 1960.

A centrifugal accelerator is a practical way of obtaining sustained measurable acceleration greater than 1 g. It is the best method of studying the high "g" effects to which accelerometers are subjected. The author describes techniques developed to interpret accelerometer linearity data obtained from a precision centrifuge, using a basic output equation for an inertial-quality accelerometer that takes into account critical error sources.

Adjusting on-off controls

From "Optimum Performance of Two-Step Action Controllers With Feedback", by W. Bottcher. Regelungstechnik, October 1960, pp. 340-344. In German.

The maximum permissible deviation in balance condition becomes the criterion for the limits of application of on-off controllers. The improved control by means of delayed or delayed reset feedback is explained by examples with an analog computer. Instructions for adjustment enable direct setting of the controller in compliance with the transient response of the plant.

NEW BOOKS

Communication and control

LECTURES ON COMMUNICATION SYSTEM THEORY. *Edited by Elie J. Baghdady, 180 pp. Published by the McGraw-Hill Book Co., Inc., New York, $12.50.*

What value will the control engineer find in a book devoted to communication theory? Because of the increasing trend toward large, complex, integrated control systems required to perform to high standards of precision and reliability, the use of digital computers is now commonplace, and it is no longer unusual for the control system to include a radio link. Consequently the concepts of random noise, information handling, ergodic hypothesis, signal-to-noise ratio, transmission rate, and optimum coding that were heretofore solely in the province of the communication engineer must also be considered by the control system designer.

This book, based on a special summer seminar offered at MIT in 1959, is a well integrated presentation of approaches to the design of modern communication systems. It contains 23 chapters, each written by a recognized expert in the communication field, including Davenport, Eleas, Faro, and Siebert, among others. Many chapters represent new results of the author's personal research, and much of the material has been obtainable previously only in scattered papers and reports.

This is definitely not intended for a beginner in modern communication theory. It would have been impossible to treat the range of subjects covered from a completely elementary standpoint and still have a book of reasonable size. However, it should prove of value not only as a reference for engineers with basic experience in the field, but also as a graduate text.

Marvin P. Pastel

Rotating amplifier

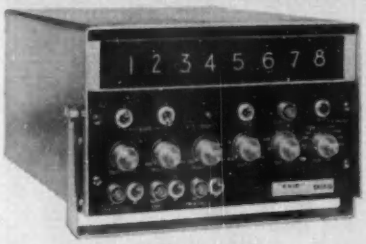
THE AUTODYNE—A NEW ELECTRICAL MACHINE, *2nd Ed. Otto Benedikt, Technical University, Budapest, 193 pp. Published by Pergamon Press, New York. $8.50.*

The autodyne, a new rotating amplifier, was developed by the author and his associates in the USSR and has been used in Europe as a power converter and control device. This tells in detail how the familiar rotary

ERIE Instrumation

MODEL 925

. . . the counter that remembers!!



SOLID STATE

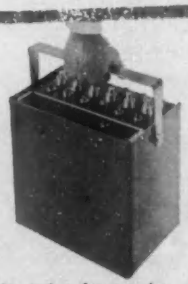
20 MC

UNIVERSAL COUNTER-TIMER

All new . . . the rugged, compact Model 925 is designed to offer the ultimate in reliable counting of periodic or random electrical events and precise measurement of Frequency, Period and Time Intervals. *Built-in memory* provides readout storage, continuous display while counting, more frequent sampling and less operator eye fatigue. Modular construction.

OUTSTANDING FEATURES:

- IN-LINE NIXIE READOUT
- 8 DIGIT MEMORY — No Blinking
- SENSITIVITY — .1V RMS — All 3 Channels
- THREE DC AMPLIFIERS
- HIGH INPUT IMPEDANCE
- AUTOMATIC DECIMAL POINT
- ONLY 3½" RACK SPACE (Model 925-R)
- DECADE TIME BASE — No Adjustments
- STABILITY — 1 Part In 10⁸/Day; 5 Parts In 10⁸/Week



ONE HAND PORTABILITY

Write today for complete specifications on the Model 925 or Model 925-R (Rack Model) — the ideal instrument for laboratory or industrial applications.

Quality Where It Counts

ERIE Instrumation

ERIE-PACIFIC, DIV. OF ERIE RESISTOR CORP.
12932 South Weber Way, Hawthorne, Calif.
ORegon 8-5418 • TWX HAW CAL 4006

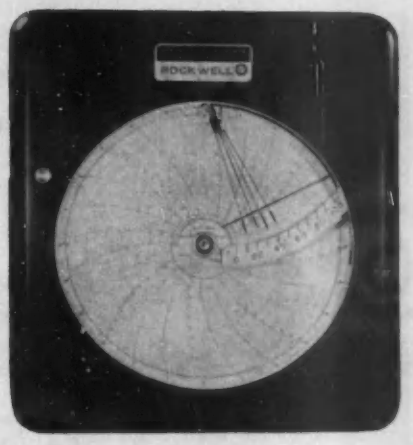
CIRCLE 185 ON READER SERVICE CARD

ROCKWELL-REPUBLIC

MP-12 Analogger combines continuous integrator with 3-15 psig square root extracting receiver

Rockwell-Republic's MP-12 Analogger is a one-to-four pen, 12" circular chart pneumatic receiver recorder. It offers a 3–15 psig square root extracting receiver and a continuous integrator, making it ideal for flow measurement.

The receiver converts a 3–15 psig differential pressure signal to a linear flow record. The integrator, based on Rockwell-Republic's time-proven watt-hour meter principle, catches swings and integrates all of the flow to provide an up-to-the-moment total.



INTERCHANGEABLE PLUG-IN RECEIVERS

The MP-12 Analogger's quadrant design permits a wide variety of recording and integrating combinations to meet your exact needs. For example, up to four completely unitized plug-in receivers may be quickly and easily installed for recording process variables. Or, Rockwell-Republic continuous integrators may be employed in either or both of the upper quadrants.

LIGHTWEIGHT AND COMPACT

Every aspect of the MP-12 Analogger's design from its aluminum case to its compact (requires only 15⅝" x 17⅜" of panel area) construction makes for efficient panel utilization. All connections are at the rear of the case.

ACCURATE CALIBRATION

The MP-12 Analogger's basic receivers are factory calibrated to within ±0.5% of chart range span. All adjustment points require only a screwdriver to make receiver output settings.

For more information about the MP-12 Analogger and other Rockwell-Republic instruments and controls, just mail the coupon. RF-27

REPUBLIC INSTRUMENTS AND CONTROLS
more fine products by
ROCKWELL

Please send latest literature on the following:

- ☐ MP-12 Analogger
- ☐ Process Transmitters
- ☐ Controllers
- ☐ VRC Ratio Computer
- ☐ Control Stations
- ☐ Recorders
- ☐ Control Valves
- ☐ Drive Units
- ☐ V-5 Gauges
- ☐ Desuperheating & Pressure Reducing Systems
- ☐ Flow Meters
- ☐ Electronic Control Systems
- ☐ Pneumatic Control Systems

Name_____ Title_____

Company_____

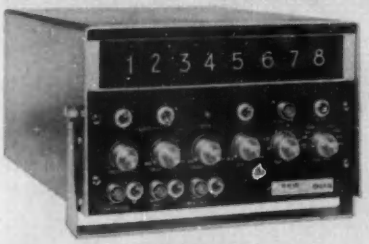
Address_____

City_____ Zone_____ State_____

Republic Flow Meters Co. *(Subsidiary of Rockwell Manufacturing Company)*
2240 Diversey Parkway, Chicago 47, Illinois

CIRCLE 165 ON READER SERVICE CARD

ERIE
Instrumation
MODEL 925
. . . the counter
that remembers!!



SOLID STATE
20 MC
UNIVERSAL COUNTER-TIMER

All new . . . the rugged, compact Model 925 is designed to offer the ultimate in reliable counting of periodic or random electrical events and precise measurement of Frequency, Period and Time Intervals. *Built-in memory* provides readout storage, continuous display while counting, more frequent sampling and less operator eye fatigue. Modular construction.

OUTSTANDING FEATURES:

- IN-LINE NIXIE READOUT
- 8 DIGIT MEMORY — No Blinking
- SENSITIVITY — .1V RMS — All 3 Channels
- THREE DC AMPLIFIERS
- HIGH INPUT IMPEDANCE
- AUTOMATIC DECIMAL POINT
- ONLY 3½" RACK SPACE (Model 925-R)
- DECADE TIME BASE — No Adjustments
- STABILITY — 1 Part In 10⁸/Day; 5 Parts In 10⁸/Week

ONE HAND PORTABILITY

Write today for complete specifications on the Model 925 or Model 925-R (Rack Model) — the ideal instrument for laboratory or industrial applications.

Quality Where It Counts
ERIE
Instrumation
ERIE PACIFIC, DIV. OF ERIE RESISTOR CORP.
12932 South Weber Way, Hawthorne, Calif.
ORegon 8-5418 • TWX HAW CAL 4006

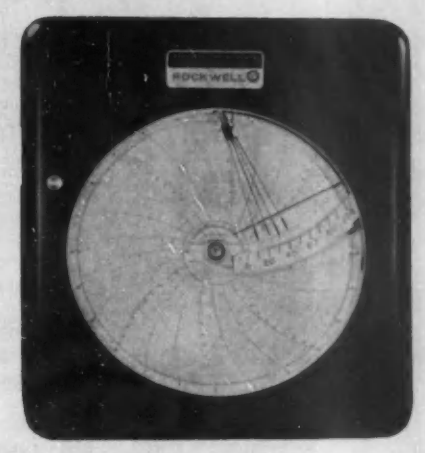
CIRCLE 185 ON READER SERVICE CARD

ROCKWELL-REPUBLIC

MP-12 Analogger combines continuous integrator with 3-15 psig square root extracting receiver

Rockwell-Republic's MP-12 Analogger is a one-to-four pen, 12" circular chart pneumatic receiver recorder. It offers a 3–15 psig square root extracting receiver and a continuous integrator, making it ideal for flow measurement.

The receiver converts a 3–15 psig differential pressure signal to a linear flow record. The integrator, based on Rockwell-Republic's time-proven watt-hour meter principle, catches swings and integrates all of the flow to provide an up-to-the-moment total.



INTERCHANGEABLE PLUG-IN RECEIVERS

The MP-12 Analogger's quadrant design permits a wide variety of recording and integrating combinations to meet your exact needs. For example, up to four completely unitized plug-in receivers may be quickly and easily installed for recording process variables. Or, Rockwell-Republic continuous integrators may be employed in either or both of the upper quadrants.

LIGHTWEIGHT AND COMPACT

Every aspect of the MP-12 Analogger's design from its aluminum case to its compact (requires only 15¾" x 17¾" of panel area) construction makes for efficient panel utilization. All connections are at the rear of the case.

ACCURATE CALIBRATION

The MP-12 Analogger's basic receivers are factory calibrated to within ±0.5% of chart range span. All adjustment points require only a screwdriver to make receiver output settings.

For more information about the MP-12 Analogger and other Rockwell-Republic instruments and controls, just mail the coupon. RF-27

REPUBLIC INSTRUMENTS AND CONTROLS
more fine products by
ROCKWELL

Please send latest literature on the following:

- ☐ MP-12 Analogger
- ☐ Process Transmitters
- ☐ Controllers
- ☐ VRC Ratio Computer
- ☐ Control Stations
- ☐ Recorders
- ☐ Control Valves
- ☐ Drive Units
- ☐ V-5 Gauges
- ☐ Desuperheating & Pressure Reducing Systems
- ☐ Flow Meters
- ☐ Electronic Control Systems
- ☐ Pneumatic Control Systems

Name _____ Title _____
Company _____
Address _____
City _____ Zone _____ State _____

Republic Flow Meters Co. *(Subsidiary of Rockwell Manufacturing Company)*
2240 Diversey Parkway, Chicago 47, Illinois

CIRCLE 165 ON READER SERVICE CARD

NEW BOOKS

converter was turned into a machine that has automatic stabilization characteristics and can replace a motor driven amplidyne. Two introductory chapters describe early attempts to alter the synchronous converter to provide a controlled source of dc. After several schemes proved inefficient and impractical, the investigators added direct and quadrature excitation fields to the stator and created the autodyne.

Technical aspects are well presented, and the mathematical treatment is, for the most part, easy to follow. Good sketches, phasor diagrams, and characteristic curves add meaning to the discussion. Short chapters explain how feedback impulses maintain synchronous operation; how the autodyne maintains accurate automatic control; and problems of stability, transients, and commutation.

Many readers concerned with industrial control will welcome this description. It not only focuses attention on a new control unit but emphasizes the importance of a most remarkable power converter now rapidly disappearing, whose redesign may prove valuable in a field for which it was not originally intended.

Charles S. Siskind
Purdue University

All about analogs

ANALOG COMPUTATION LIBRARY. *Stanley Fifer.* 4 *vols.*, 1384 *pp. Published by the McGraw-Hill Book Co., Inc., New York.* $39.50.

To paraphrase an old joke, this exhaustive treatise tells more about analog computing than most of us care to know. It provides the most thorough coverage of components, computers, and techniques that this reviewer has ever seen.

Nine out of 30 chapters deal with components used in analog computers, from dc amplifiers and linear pots to function generators and analog-digital converters. The author deserves special commendation for devoting considerable space to pot loading errors and their compensation, a topic covered only briefly in most analog computer books.

Fifer devotes four chapters to analog computers other than the conventional dc electronic differential analyzer. He describes, among others, thermal and potential analogs, ac network analyzers, and mechanical differential analyzers. A fascinating his-

NEW BOOKS

torical sidelight is Lord Kelvin's own account of using his mechanical differential analyzer to solve a second order differential equation.

The remainder of the four volumes is devoted to computing techniques, and it is here that the work really shines. It covers all the usual topics and many others.

There are numerous examples worked out in detail and a comprehensive collection of problems. The author's encyclopedic knowledge of the field has been buttressed by extensive research, shown by the tremendous number of references in each chapter. Mr. Fifer has made a truly memorable contribution to the analog computer literature.

Leslie R. Axelrod
The Powers Regulator Co.

Solving with numbers

NUMERICAL METHODS FOR SCIENCE AND ENGINEERING. *Ralph G. Stanton, 288 pp. Published by Prentice-Hall, Inc., Englewood Cliffs, New Jersey.* $9.00.

This is an extremely informative and useful little book. The author states that his approach is primarily "how to do," and he is consistent in this. Starting with the basic concepts of finite, divided, and central differences, he builds working techniques for numerical solution of practical problems, largely on the basis of illustrative examples coupled with brief verbal explanations.

Scattered through the book are a number of very helpful statements that are unusual in technical books but greatly appreciated by students: "Actually, neither the divided difference formula nor the Gauss formulae are of great practical use; however, they serve as intermediate steps. . ." (p. 35) or again, "Some engineers and pure mathematicians . . . labor under the illusion that determinants are a practical method of solving equations. . . . Even electronic computers, . . . find determinants too awkward to employ." (p. 163).

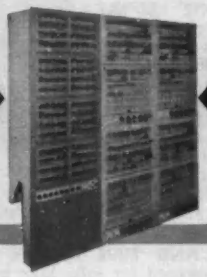
Besides being very good for self study and a good text for some courses, this book could also be used as a reference for many computational purposes. The material it contains is certainly prerequisite to an intelligent approach to digital computer programming.

George J. Thaler
U. S. Naval Postgraduate School

TRANSISTORIZED DIGITAL SYSTEMS

Digital Systems—The NAVCOR systems approach is one encompassing modular units of standard NAVCOR plug-in modules. This permits future change or expansion of your requirements—minimizes the possibility of obsolescence. Every NAVCOR system includes indicators on all memory elements for easy checkout and maintenance.

NAVCOR development and production facilities can expedite your digital system program—offering a unique combination of technical experience and production economy.



Creative engineering by NAVCOR has successfully developed the 100 Series transistorized modules for digital test equipment and prototype development, and the newer 300 Series card modules for constructing complete data handling systems. Delivered complete and attractively packaged, these economical systems modules are ready to operate with a minimum of inter-unit wiring.

NAVCOR can engineer and manfacture complete systems to your requirements. Years of experience, devoted exclusively to semiconductor digital systems design, have produced hundreds of thousands of operating logic stages.

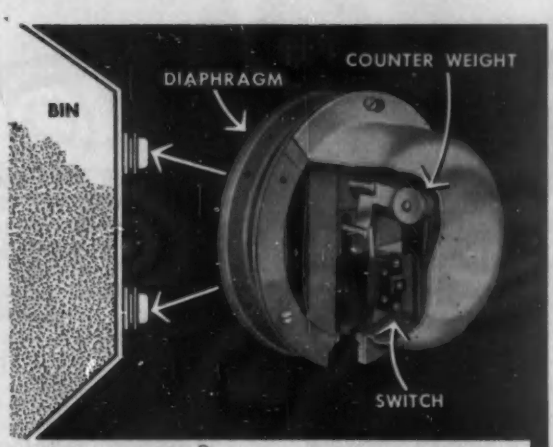
FREE

Send for complete data and specifications on the 300 Series systems blocks.

Navcor

NAVIGATION COMPUTER CORP.
VALLEY FORGE INDUSTRIAL PARK
NORRISTOWN, PA.
Glendale 2-6531

CIRCLE 189 ON READER SERVICE CARD



BIN-DICATOR® PAYS FOR ITSELF FIRST TIME IT PREVENTS BIN OVERFLOW, CONVEYOR CLOG, ELEVATOR CHOKE-UP, MACHINERY DAMAGE, REPAIR SHUT-DOWN

If you handle bulk material you probably need Bin-Dicators. The nominal cost of this protection and automatic control makes it the lowest-cost modernization you can buy. Available with Explosion-Proof Switch.

THE BIN-DICATOR CO.
17190-F3 Denver • Detroit 24, Mich.

Write for free copy of catalog BD-15 or call TUxedo 2-3000

WE SELL DIRECT • PHONE ORDERS COLLECT

CIRCLE 190 ON READER SERVICE CARD


Up to 262,000 counts per revolution


Up to 32,000 counts per revolution


Lightweight Airborne Model Up to 32,000 counts per revolution

DIGISYN®

PHOTOELECTRIC INCREMENTAL POSITION TRANSDUCERS

Performance:

- Digital pulse output from rotary motion input
- Resolution to 262,000 counts per revolution
- Forward and backward rotation counts
- Provisions for zero reset
- Linear & Non-Linear functions

Typical Applications:

- Precision machines — servo control
- Pulse tachometers
- Shaft position control and monitor
- Circle dividing
- Stable platform position monitor

COMPLETE LINE OF DIRECT-READING BINARY AND SPECIAL ENCODERS AND ACCESSORY EQUIPMENTS ALSO AVAILABLE

Write or call (Boston) COpley 7-8425 for further information

WAYNE-GEORGE CORPORATION
(ADCON DIVISION)
588 COMMONWEALTH AVENUE • BOSTON 19, MASS.

CIRCLE 169 ON READER SERVICE CARD

MEETINGS

AUGUST

Gordon Research Conference on Instrumentation, Colby Junior College, New London, New Hampshire Aug. 14-18

Second International Electronic Circuit Packaging Symposium, University of Colorado, Boulder, Colo. Aug. 16-18

Western Electronic Show and Convention (WESCON), sponsored by IRE and WCEMA, Cow Palace, San Francisco, Calif. Aug. 22-25

International Heat Transfer Conference, sponsored by ASME, AIChE, University of Colorado, Boulder, Colo. Aug. 28-Sept. 1

SEPTEMBER

Third Congress, International Association of Analog Computation, Belgrade, Yugoslavia Sept. 4-9

International Language Translation Conference, National Physical Laboratory, Teddington, Middlesex, England Sept. 5-8

International Data Processing Exhibit (in conjunction with 16th National Meeting of Association for Computing Machinery), Statler Hilton Hotel, Los Angeles, Calif. Sept. 6-8

Institute of Radio Engineers, National Symposium on Space Electronics and Telemetry, University of New Mexico, Albuquerque, N. M. Sept. 6-8

Joint Nuclear Instrumentation Symposium, sponsored by ISA, AIEE, IRE, North Carolina State College, Raleigh, N. C. Sept. 6-8

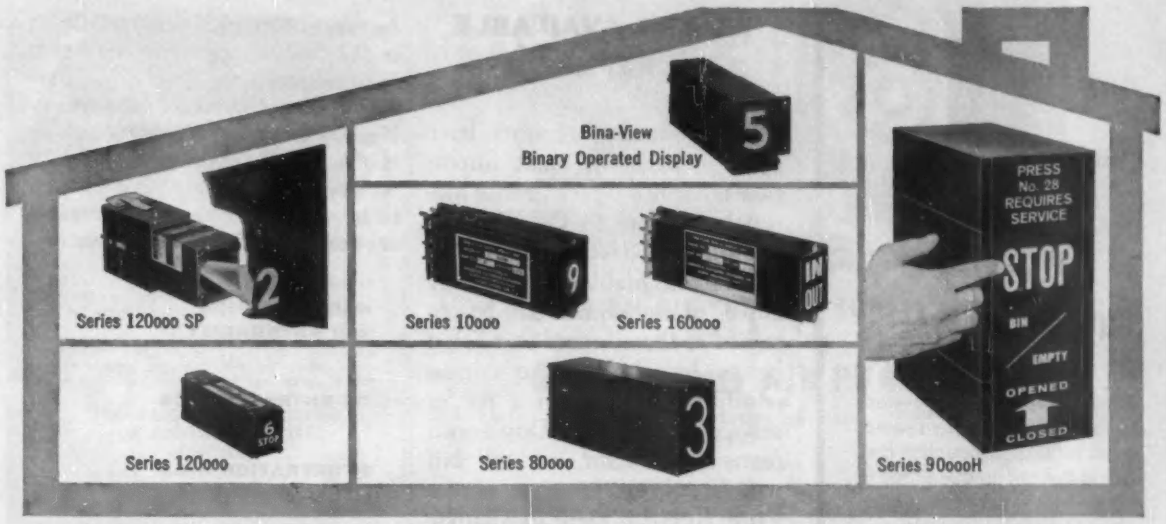
Instrument Society of America, 16th Annual Instrument-Automation Conference and Exhibit, Biltmore Hotel and Memorial Sports Arena, Los Angeles, Calif. Sept. 11-15

Third International Cybernetics Congress, Namur, Belgium Sept. 11-15

Industrial Electronics Symposium, sponsored by IRE, AIEE, ISA, Bradford Hotel, Boston, Mass. Sept. 21-22

OCTOBER

Institute of Radio Engineers, Seventh National Communications Symposium, Utica, N. Y. Oct. 2-4



READOUTS THAT DO MORE THAN DISPLAY NUMBERS

I.E.E.'s complete line of rear-projection readouts display words, numbers, symbols, and color. The alpha-numeric Bina-View readout is self-decoding and operates direct from binary output. And all can satisfy human factors requirements!

The engineering staff and facilities of Industrial Electronic Engineers, Inc. have approached the problem of readouts as one of visual communications, the case in point being that numbers are only one form in a host of methods in visual communications. The engineering talent at I.E.E. work under the formula that the more forms of visual communications that are available the less chance there is for communicative breakdown. *In a word; complete.*

complete! under the roof

Your inquiry to complete readout visual communications is invited.

INDUSTRIAL ELECTRONIC ENGINEERS, Inc.
5528 Vineland Avenue, North Hollywood, California

CIRCLE 192 ON READER SERVICE CARD

ANALOG CIRCUIT DESIGN

The strictly realistic art of analog circuit design relates directly to our projects in inertial guidance. If you have fine-line experience in the design and development of transistorized circuits for servo and analog computer applications used in I.G. systems, write to Mr. Donald E. Krause.

Qualified applicants will be considered regardless of race, creed, color or national origin.

LITTON SYSTEMS, INC. Guidance & Control Systems Div.
Woodland Hills, California

If you live in the EAST or MIDWEST write or phone the LITTON Research & Engineering Staff Representative nearest you:

Mr. Harry Laur,
221 Crescent Street,
Waltham, Mass.
TWinbrook 9-2200.

Mr. Garrett Sanderson,
375 Park Ave.,
New York City, New York.
PLaza 3-6060.

Mr. Robert L. Baker,
360 No. Michigan Ave.,
Chicago, Ill. ANdover 3-3131

WHAT'S AVAILABLE IN REPRINTS

The following reprints have been prepared to make important reference-type editorial material available to CONTROL ENGINEERING readers in convenient filable form. Single copies of any reprint can be obtained at the nominal cost listed below by circling the corresponding numbers on a reader service card, p. 149. Don't send money with card, we will bill you later. For multiple copies write Reprint Dept. Quantity rates will be quoted on request.

512—Ready Reference Data Files—IV, 20 pp. Contains Data Files 37 to 48. Subjects range from information display to semiconductor voltage regulators to loaded parallel-T filters. 50 cents.

511—Industrial Process Chromatographs: What they do, How they work, Who makes them, 14 pp. Reviews basics of chromatographic techniques including latest refinements to increase sensitivity and reduce analysis time of this versatile stream analyzer, describes major components and their functions, and highlights operation and specific features of six commercially available chromatographs. 50 cents.

510—The Use of Digital Computers in Science, in Business, and in Control, 112 pp. A collection of 14 articles published over a two-year period as the Digital Applications Series. Prominent authorities cover the application, programming, overall system design, and commercial availability of digital computers in all phases of business, industry, and military. (An old reprint but with basic and practical content of value today). $3.00.

509—Applying Incremental Servos, 24 pp. Incremental servos offer many advantages in closed-loop systems. A grouping of five basic articles compares stepping and stepless control, describes the operation and analysis of solenoid-ratchet and phase-pulsed synchronous steppers, shows 16 applications of stepping motors, tabulates pertinent characteristics of available stepping motors, and discusses the problems of interlocking the devices. 65 cents.

508—Transistor Switches for Industrial Service, March 1961, 24 pp. Industry requires reliable, inexpensive, and fast switching devices. This special report thoroughly covers one possible solution to this requirement—transistor logic modules packaged for industrial use. Topics include how transistors perform logic functions, available systems and components, tips on selection and use, and case studies of industrial applications. 65 cents.

507—Tips on the Use of Electromechan-

(Continued on page 174)

REPRINTS cont'd

ical Relays, 24 pp. Compilation of five articles presents practical information on the design, test, and use of relay control systems. Topics covered include: testing relay electrical reliability, improving system reliability, narrowing relay differential, logical synthesis of systems, and verifying relay control circuits. 65 cents.

506—What You Should Know About Adaptive Systems, 17 pp. Is there such a thing as an adaptive control system? What approaches have been taken? What does the future hold? These are the questions the author answers in this three-article reprint, in sufficient detail and with sufficient references to provide a basic grounding in this latest area of control engineer interest. 50 cents.

505—The Basics of Optimum Response Relay Servos, 17 pp. Three part series summarizes all of the important design techniques that have been used to optimize the response of relay servos. The reprint describes the development of the optimum switching criteria, and outlines the progress that has been made in implementing this theory with hardware for second order and higher order systems. Extensive references provide a guide for further study. 50 cents.

504—System Characteristics of Modern Guidance Techniques, August 1960, 22 pp. In this special report five experts from three companies cover the system characteristics of inertial navigators, guidance radars, Doppler radar techniques, modern techniques in celestial navigation, and perceptive guidance systems. 65 cents.

503—How to Determine Stream Analyzer Dynamics, 8 pp. Package of two articles shows how analyzers can introduce dynamic errors, how to determine analyzer dynamics, and how to improve performance. The instrument used is a differential refractometer but techniques can be extrapolated to other types of analyzers. 40 cents.

502—Survey of Dynamic Display Techniques, 20 pp. The function of these newly developed techniques is to put up-to-date information in the hands of human operators of control systems when the information changes at a high rate. Both basic approaches and commercial hardware are discussed for cathode ray tube displays, optical systems, and miscellaneous devices ranging from TV pickup to matrix cells. 50 cents.

501—Six Transducers for Precision Position Measurement, May 1960, 6 pp. Explains operation and gives practical application hints for six precision position transducers: pin-and-pawl mechanism, magnetic bench-mark system, resolver-type transducer, electrostatic transducer, coded-disc devices, and diffraction gratings. 30 cents.

500—Ready Reference Data Files—I, II, III, 76 pp. The feature here is a special rate for those who purchase all of the Data Files published in CONTROL ENGINEERING through April 1960. The 36 articles included in this package cover analysis, design, and application short-cuts for all phases of the control field. Everyone can use this timeless reference material. $1.35.

(*Continued on page 176*)

Photo courtesy: Republic Aviation

Effective Engineer Recruitment Advertising Depends on Engineering Readership

In the wide field of measurement and control and information systems; in its specialized areas of research, design, development, computer engineering, programming, systems analysis, instrumentation, and the whole range of disciplines in this dynamic technology, Control Engineering's selective, paid circulation assures that

The engineers you need are the engineers who read

Write for the new 52-page booklet **"Recruiting Engineers"**
Address: David Hawksby, Classified Advertising Div.
Control Engineering, Post Office Box 12, New York 36, N. Y.

Control
ENGINEERING
INSTRUMENTATION AND CONTROL SYSTEMS
A McGRAW-HILL PUBLICATION

REPRINTS cont'd

499—Ready Reference Data Files—III, 28 pp. Includes the third dozen Data Files published in CONTROL ENGINEERING. Topics range from control of metal properties with eddy currents to electrically signaled valve actuators to stabilization of sampled data systems. 60 cents.

498—Ready Reference Data Files—II, 24 pp. Includes the second dozen data files published in CONTROL ENGINEERING. Topics covered range from analyzing hydraulic servos graphically to using silicon diodes as protective devices. 50 cents.

497—Ready Reference Data Files—I, 24 pp. Includes the first 12 data files published in CONTROL ENGINEERING—a diversity of topics from system reliability through the cost of industrial temperature-measuring systems. Each shows how to solve a particular problem. 50 cents.

496—How to Specify Instrument Accuracy, 8 pp. This basic reprint is aimed at helping the user and maker to develop clear and mutual agreement on allowable instrument errors. Discussions of uncertainties of zero, scale factor, and instantaneous slope aid in the intelligent specification of allowable errors and preferred test procedures. 40 cents.

494—How to Use the Root Locus in Control System Design, 12 pp. Another reprint that translates theory into practice. Eight simple rules make locus construction easy, even including the effects of distance-velocity lags. Articles show how to interpret the locus diagram, determine transient response, and use locus techniques with multiloop systems. 45 cents.

489—Fundamentals of Multivibrators, 12 pp. Multivibrators are the electronic equivalent of the double-throw electromechanical relay and can perform substantially the same functions (memory, logic, gating, counting), but at enormously higher speeds. They can be built around vacuum tubes, transistors, square-loop magnetic materials, neon tubes, thyratrons, and cryotrons. This covers a broad selection of multivibrator circuits. 45 cents.

488—A Roundup of Control System Test Equipment, 24 pp. Specialized control system test equipment divides into three classes: 1) devices that only generate a test signal, 2) systems that both disturb the system and provide a means for evaluating response, and 3) devices that only evaluate control system response. 60 cents.

487—Survey of Ac Adjustable-Speed Drive Systems, June 1959, 16 pp. Regarded as constant speed devices, multispeed ac actuators actually take many efficient forms. The recent resurgence of interest in these ac adjustable-speed systems prompted this comprehensive coverage of pole-changing techniques, armature resistance control of wound-rotor motors, slip-frequency injection, use of eddy-current couplings, etc. 50 cents.

486—A New Way to Select the Best Control Valve, 16 pp. This three-article reprint gives rules for selecting the right valve characteristics based on static and dynamic considerations, takes into account the influence of piping on valve performance, and tackles the problem of sizing valves for maximum flow and for control rangeability. 50 cents.

EMPLOYMENT OPPORTUNITIES

EMPLOYMENT **Control ENGINEERING** OPPORTUNITIES

INSTRUMENTATION AND CONTROL SYSTEMS

MONTHLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

This Qualification Form is designed to help you advance in the control industry. It is unique and compact. Designed with the assistance of professional personnel management, it isolates specific experience in instrumentation and deals only in essential background information. The advertisers listed here are seeking professional experience. Fill in the Qualification Form below.

STRICTLY CONFIDENTIAL

Your Qualification form will be handled as "Strictly Confidential." Our processing system is such that your form will be forwarded within 24 hours to the proper executives in the companies you select. You will be contacted at your home by the interested companies.

WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *PLEASE PRINT CLEARLY*
6. Mail to: D. Hawksby, Classified Advertising Div., Control Engineering, Box 12, New York 36, N. Y. (No charge, of course).

COMPANY	SEE PAGE	KEY #
AIRCRAFT ARMAMENTS, INC. Cockeysville, Maryland	204*	1
A M F ATOMICS Greenwich, Connecticut	176	2
BURNHAM VAN SERVICE Columbus, Georgia	176	3
ESQUIRE PERSONNEL Chicago, Illinois	176	4
LITTON SYSTEMS INC. Guidance & Control Systems Div. Woodland Hills, California	171	5

* This Advertisement appeared in the July Issue.

(cut here) (cut here)

CONTROL ENGINEERING MONTHLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME .....

HOME ADDRESS .....

CITY..... ZONE..... STATE.....

HOME TELEPHONE.....

Education

PROFESSIONAL DEGREE(S) .....

MAJOR(S) .....

UNIVERSITY .....

DATE(S) .....

FIELDS OF EXPERIENCE (Please Check)

861

- ☐ Aerospace Control
- ☐ Components
- ☐ Computer Design
- ☐ Computer Application
- ☐ Computer Programming
- ☐ Control Theory
- ☐ Data Communication
- ☐ Display
- ☐ Electronic Circuitry
- ☐ Flight Instrumentation
- ☐ Guidance Systems
- ☐ Hydraulics
- ☐ Industrial Control
- ☐ Logic Design
- ☐ Machinery Control
- ☐ Man Machines
- ☐ Motor Control
- ☐ Nuclear
- ☐ Numerical Control
- ☐ Optics
- ☐ Pneumatics
- ☐ Process Control
- ☐ Process Instrumentation
- ☐ Servomechanisms
- ☐ Simulation
- ☐ Solid State Devices
- ☐ Switching
- ☐ Systems Analysis
- ☐ Other .....

CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	.....	.....
RESEARCH (Applied)	.....	.....
SYSTEMS (New Concepts)	.....	.....
DEVELOPMENT (Model)	.....	.....
DESIGN (Product)	.....	.....
MANUFACTURING (Product)	.....	.....
FIELD (Service)	.....	.....
SALES (Proposals & Products)	.....	.....

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12

ADVERTISING IN THIS ISSUE

•

CLASSIFIED ADVERTISING
F. J. Eberle, Business Manager

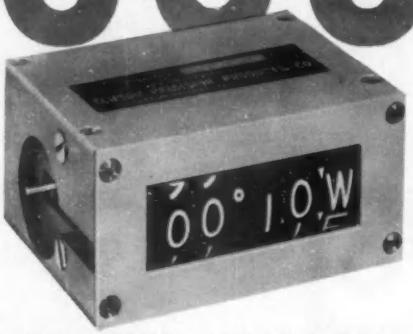
ADVERTISERS INDEX

DISTRICT MANAGERS

ATLANTA 9: R. H. Powell, 1375 Peachtree Street N.E., 875-0523
BOSTON 16: Peter B. Stien, McGraw-Hill Bldg., Copley Square, COngress 2-1160
CHICAGO 11: Milton J. Steinbraker, 645 N. Michigan Ave., MOhawk 4-5800
CLEVELAND 13: Edward H. Walker Jr., 55 Public Square, SUperior 1-7000
DALLAS 1: John Grant, 2100 Vaughn Bldg., 1712 Commerce St., Riverside 7-9721
DENVER 2: John W. Patten, Tower Bldg., 1700 Broadway, ALpine 5-2981
HOUSTON 25: Gene Holland, W-724 Prudential Bldg., JAckson 6-1281
LOS ANGELES 17: Gene A. Fruhling, 1125 W. Sixth St., HUntley 2-5450
NEW YORK 36: J. M. Morris, R. Bauser, 500 Fifth Ave., OXford 5-5959
PHILADELPHIA 3: William F. Buehl, Six Penn Center Plaza, LOcust 8-4330
SAN FRANCISCO 11: W. C. Woolston, 255 California St., DOuglas 2-4600
LONDON W. 1, ENGLAND: Malcom Thiele, 34 Dover St.
FRANKFURT-MAIN, GERMANY: S. Kimes, 86, Westendstrasse
GENEVA, SWITZERLAND: M. R. Zeynel, 2 Place du Port

ANOTHER NEW PRODUCT FROM CPPC

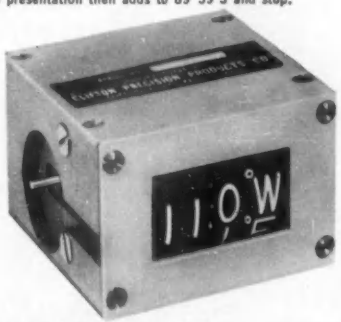
COUNTERS



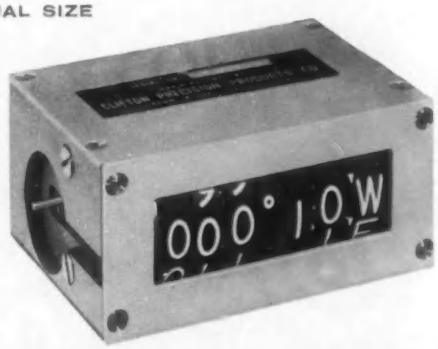
with LARGEST numerals (1/4") in the LEAST panel space

LATITUDE COUNTER 39100000—This miniature latitude counter provides latitude indications adding from 00°00'N to 89°59' N and stop in north presentation. With reversed rotation of input shaft north flag (N) switches to south (S) at 00°00' and presentation then adds to 89°59'S and stop.

ALL COUNTERS
SHOWN ACTUAL SIZE



MAGNETIC VARIATION COUNTER 39300000—This miniature magnetic variation counter provides variation indications adding from 000° to 179°W in west presentation. With continued rotation of input shaft in same direction the west flag (W) switches to east (E) and the presentation then subtracts from 179°E to 000°E. Continued rotation shifts the flag back to west again and presentation is added at 000°W to 179°W. Reverse rotation reverses presentation.



LONGITUDE COUNTER 39200000—This miniature longitude counter provides longitudinal indications adding from 000°00' to 179°59'W in west presentation. With continued rotation of input shaft in same direction the west flag (W) switches to (E) and the presentation then subtracts from 179°59'E to 000°00'E. Continued rotation shifts flag back to west again and the presentation is added at 000°00'W to 179°59'W. Reverse rotation reverses presentation.

SPECIFICATIONS

Miniature Mechanical Counters
Latitude, Longitude and Magnetic Variation Series

INPUT SPEED
800 r.p.m. maximum intermittent;
500 r.p.m. continuous

INPUT TORQUE
1.0 inches-ounces maximum at 25°C

CROSSOVER TORQUE
3.0 inches-ounces maximum at 25°C

MATERIALS
Housing: Black anodized aluminum
Drums: Diallyl Phthalate black
Internal parts and input shaft: Stainless steel

BEARINGS
ABEC 5 stainless steel ball bearings on all shafts

WEIGHT
4 ounces maximum

ROTATION
Reversible with continuous one way rotation. Fifteen revolutions of input shaft changes readings by 2°40' for the latitude and longitude counters. Fifteen revolutions of input shaft changes reading by 160° for the variation counter.

NUMERAL SIZE
.250" high: .031" line width. White characters on black. 1,000 diameter wheels per MS-33558 (ASG).

A unique crossover mechanism (on which CPPC patent is pending) has enabled CPPC to produce precision mechanical counters with no shutter and a single set of wheels. The resultant counters are of a minimum size (less than 2.5 square inches of panel space required), and yet allow the largest numerals, 1/4" high, which we have been able to discover in counters of this size and accuracy.

These counters were designed and manufactured by us for our own miniature navigation computers. They meet requirements of MIL-E-5272 and MIL-T-5422.

For information phone or write: Area 215 MAdison 2-1000, TWX LNSDWN, Pa. 1122 (U) —or our Representatives.

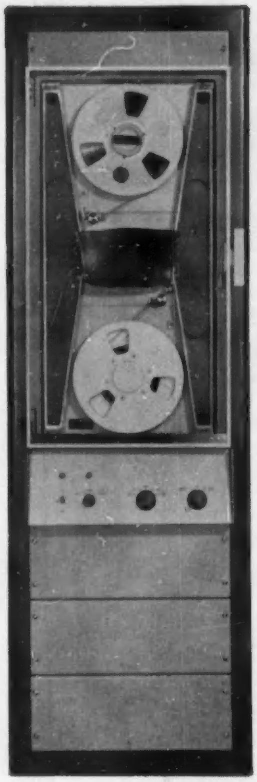
Engineers: Join the leader in the electromechanical components field. Write David D. Brown, Director of Personnel.

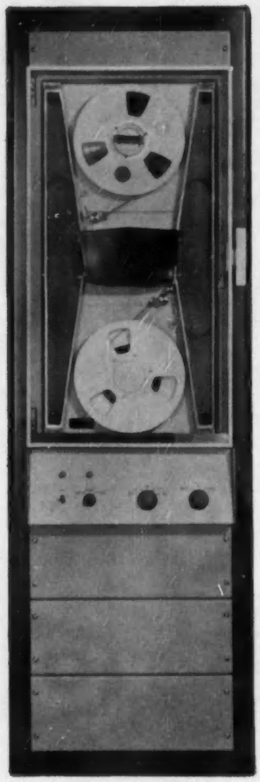
CLIFTON PRECISION PRODUCTS CO., INC.

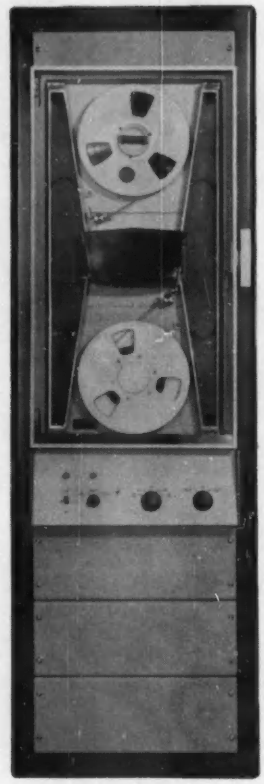
Clifton Heights, Pennsylvania

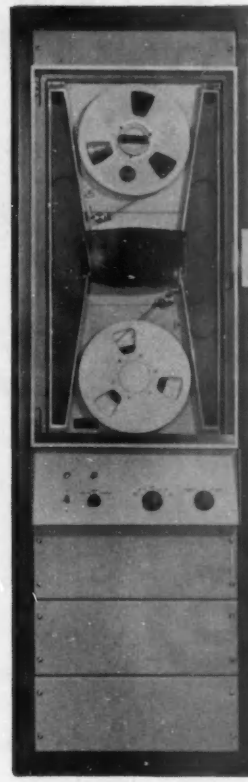
cppc SYSTEMS DIVISION

CIRCLE 180 ON READER SERVICE CARD









ON & ON & ON & ON

That's the way it goes ("it" being the Ampex TM-2 digital tape handler). On and on, with hardly a pause for maintenance. Completely new servo and tape guide systems give the TM-2 extremely long term performance stability. Improved vacuum buffer columns gently hold the tape supply and take-up loops. Specially developed inertia brakes give reliable stop times and short stop distances at high tape speeds. Start time of 2.0 ms and stop time of 1.5 ms are consistent under the most rigorous programs. And the TM-2 has a 90 Kilocycle character transfer rate. Why not send for all the facts: Ampex Computer Products Company, P.O. Box 329, Culver City, California.

AMPEX 0/1 T.M.
AMPEX COMPUTER PRODUCTS COMPANY

That's the way it goes ("it" being the Ampex TM-2 digital tape handler). On and on, with hardly a pause for maintenance. Completely new servo and tape guide systems give the TM-2 extremely long term performance stability. Improved vacuum buffer columns gently hold the tape supply and take-up loops. Specially developed inertia brakes give reliable stop times and short stop distances at high tape speeds. Start time of 2.0 ms and stop time of 1.5 ms are consistent under the most rigorous programs. And the TM-2 has a 90 Kilocycle character transfer rate. Why not send for all the facts: Ampex Computer Products Company, P.O. Box 329, Culver City, California.

AMPEX 0/1 T.M.
AMPEX COMPUTER PRODUCTS COMPANY

That's the way it goes ("it" being the Ampex TM-2 digital tape handler). On and on, with hardly a pause for maintenance. Completely new servo and tape guide systems give the TM-2 extremely long term performance stability. Improved vacuum buffer columns gently hold the tape supply and take-up loops. Specially developed inertia brakes give reliable stop times and short stop distances at high tape speeds. Start time of 2.0 ms and stop time of 1.5 ms are consistent under the most rigorous programs. And the TM-2 has a 90 Kilocycle character transfer rate. Why not send for all the facts: Ampex Computer Products Company, P.O. Box 329, Culver City, California.

AMPEX 0/1 T.M.
AMPEX COMPUTER PRODUCTS COMPANY

That's the way it goes ("it" being the Ampex TM-2 digital tape handler). On and on, with hardly a pause for maintenance. Completely new servo and tape guide systems give the TM-2 extremely long term performance stability. Improved vacuum buffer columns gently hold the tape supply and take-up loops. Specially developed inertia brakes give reliable stop times and short stop distances at high tape speeds. Start time of 2.0 ms and stop time of 1.5 ms are consistent under the most rigorous programs. And the TM-2 has a 90 Kilocycle character transfer rate. Why not send for all the facts: Ampex Computer Products Company, P.O. Box 329, Culver City, California.

AMPEX 0/1 T.M.
AMPEX COMPUTER PRODUCTS COMPANY

CIRCLE 181 ON READER SERVICE CARD